Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

UNIVERSITY
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February 1956

Fabricated Metal Parts—M & M Manual No. 124

Casting Resins Insulate and Protect Electronic Components

Continuous Cast Bronze Shapes

Asbestos-Reinforced Low Pressure Laminates

Rare Earth Stainless Steels

Bonded Fabrics for Engineering Uses

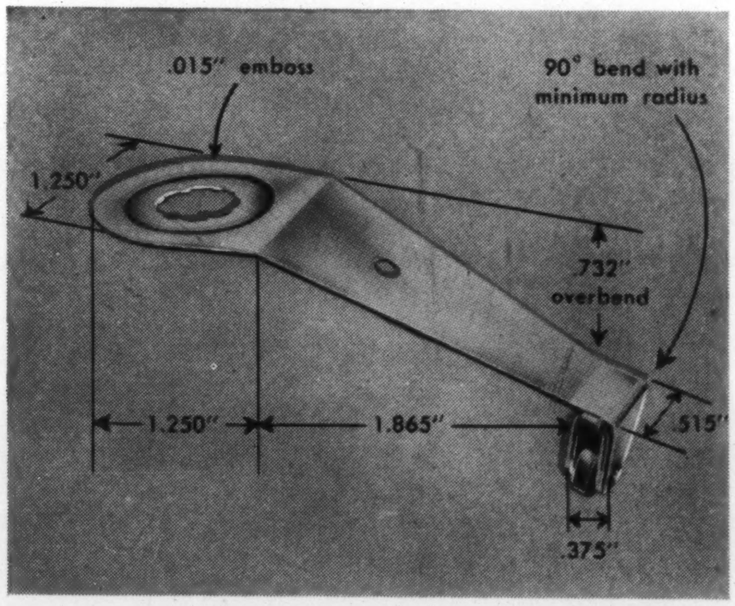
Flame-Plated Parts

PRICE FIFTY CENTS

Complete Contents—page 1

This railroad runs better, will last longer

A Type ZW Lionel Trainmaster Control has four independent variable voltage circuits, can operate four trains simultaneously.



One of the four variable voltage taps in a Type ZW Lionel Trainmaster Control, now made of .0150" thick Duraflex in spring temper. This temper in Duraflex provides the extra strength needed—with the same forming properties as conventional phosphor bronze in extra hard temper.

Lionel switched to DURAFLEX *for the hardest working parts of its Trainmaster controls*

Much of the fun of model railroading depends on the smooth, dependable performance of its controls. That's why Lionel makes its Trainmaster controls tough, precision instruments – constantly guards their quality.

Lionel had been using an ordinary phosphor bronze in the vital, hard-working variable voltage taps. But they were troubled with fractures in forming the bends. To maintain their quality standards, they considered using another alloy, at substantially increased cost.

First, however, they tried Duraflex*, Anaconda's new superfine-grain phosphor bronze. The fractures were eliminated. The press room found the forming qualities of Duraflex excellent. The Transformer Department was pleased with the reduction in rejects, found the strength and resilience better.

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Duraflex, because of its superfine-grain structure, offers greatly improved fatigue resistance and formability. It also has a finer, smoother, harder surface, plus good electrical conducting properties and high corrosion resistance. It is produced in sheet metal up to 0.062" thick and in wire up to 3/16" diameter. We will provide free samples for test purposes – specify gage and temper. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

*Trade Mark

DURAFLEX

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with 30% Greater Endurance Limit

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For more information, turn to Reader Service Card, Circle No. 318

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Materials & Methods®

Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

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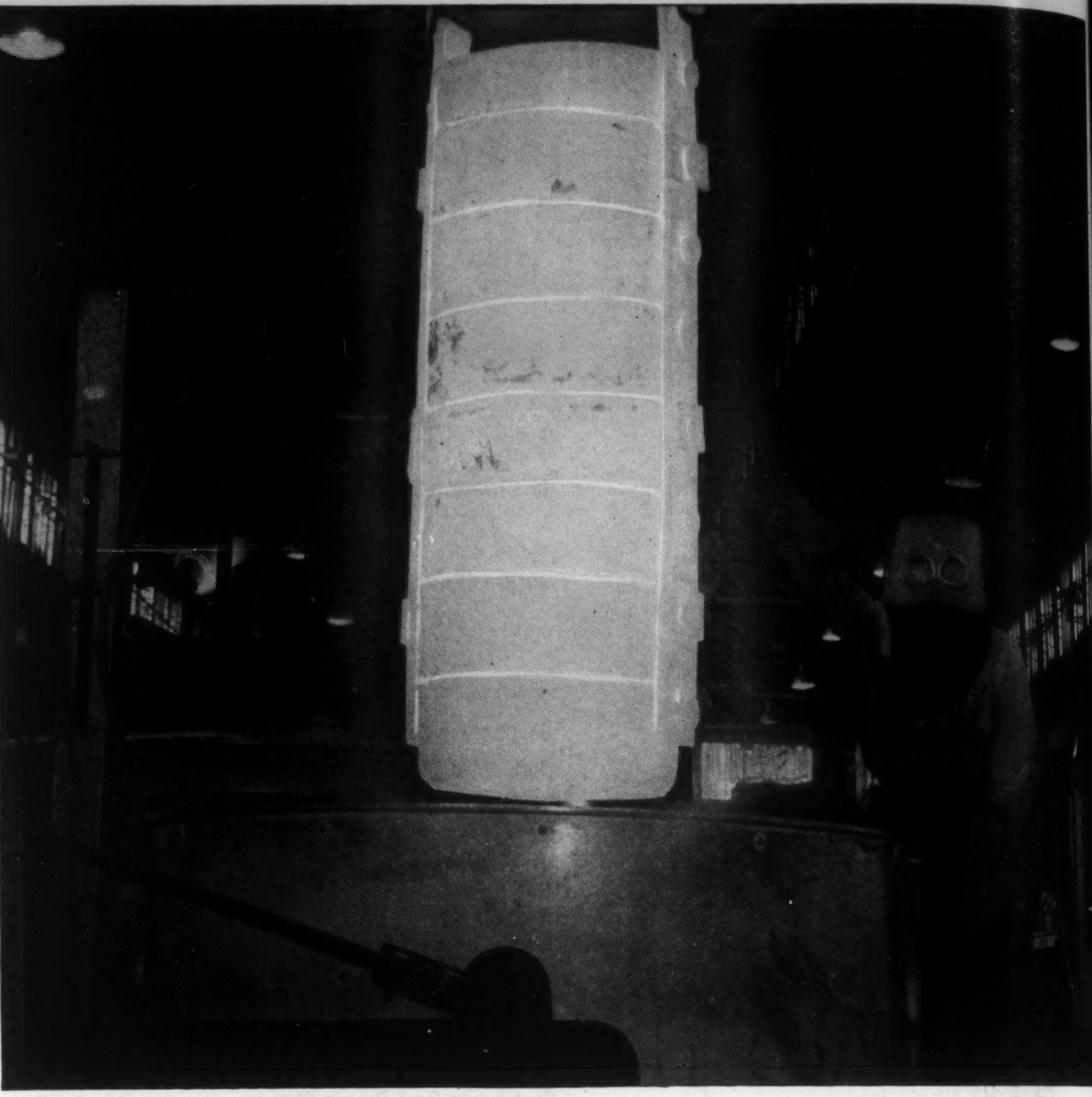


Removing heat from an Inconel retort at the Bullard Company plant. This is one of six pit type furnaces used to carburize heavy gears used in Bullard Horizontal Boring, Milling and Drilling Machines; Bullard Cut Master vertical Turret Lathes and Bullard Mult-Au-Matic vertical Chucking Machines.

Inconel triples life of pit carburizing retorts at Bullard plant

Averages 12 months' service at 1700°F ...then 6 more when repaired

Is your heat treating equipment lasting as long as it should?

If not, maybe you should try Inconel* nickel-chromium alloy.

Take what happened at the Bullard Company. Retorts up to 84″ deep, used to carburize machine tool parts at 1700°F, were failing within six months.

Then Rolock, Inc. came up with a suggestion ... wrought Inconel. This change in alloys immediately boosted retort life to 12 months. What's more, with this ni-cr alloy, these pots are being repaired by welding, to add an additional 6 months.

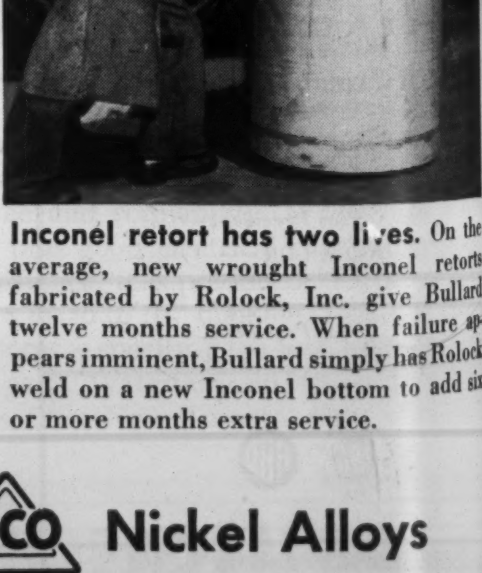
*Reg. Trademark

It often works out that way with Inconel. Not only do you get longer life to start with . . . but you also have a high degree of repair ability besides.

There are sound reasons for this. The Inconel pots resist damage by oxidation, carburization and other forms of high temperature attack. This alloy retains its useful properties to 2100° F and over in some applications. It withstands thermal shock. It retains forming and welding properties despite sustained hot service.

So maybe Inconel nickel-chromium alloy is the metal you should try next. Check with your fabricator ... or write

The International Nickel Co., Inc.
67 Wall Street New York 5, N. Y.



Inconel retort has two lives. On the average, new wrought Inconel retorts fabricated by Rolock, Inc. give Bullard twelve months service. When failure appears imminent, Bullard simply has Rolock weld on a new Inconel bottom to add six or more months extra service.

Inconel *... for long life at high temperatures* **INCO** TRADE MARK **Nickel Alloys**

For more information, turn to Reader Service Card, Circle No. 330

Materials Outlook

A PAINT SAID TO OFFER GREAT RESISTANCE to corrosion and to protect metal and wood surfaces from highly concentrated acids and alkalis, has been offered for sale. Said to be the highest priced paint in the world, quantity buyers can obtain it for $36 per gallon with $40 per gallon the price for smaller users.

A CONDUCTING PLASTIC whose resistance changes according to the amount of moisture to which it is exposed is being used in instruments to measure humidity under nearly all conditions. Electrical connections are secured by a small metallic gridwork etched on the plastic.

ASPHALT WEATHERING RESISTANCE tests have been developed and standardized by the National Bureau of Standards. Various combinations of light, water, and thermal shock were investigated for their effects on three coating grade asphalts.

A NEW PLASTIC LAMINATE, consisting of a thin 10 to 12 mil continuous layer of fluorocarbon plastic on glass cloth, can be adhesive bonded to almost any contoured surface. Offering high temperature and extreme chemical resistance vessels, ranging from rectangular plating tanks to complex reactors involving flanged pipe connections and dished heads, have been lined throughout with the material.

A FLUIDIZED COATING PROCESS provides corrosion resistant coatings of polyethylene, polyfluorocarbons, nylon, and other plastics on metallic or dissimilar plastic molded targets. Key to the process is a compressed air distribution system which maintains the plastic powder in a turbulent dense fluid state. Objects to be coated are heated above the melting point of the plastic and immersed in the fluidized bed.

APPROXIMATELY 58% OF THE METALWORKING equipment and tools in use today is at least 10 years old and another 21% is at least 20 years old according to a recent study. Significant point is that machines less than 10 years old are about a third more productive than older machines.

SOME ALUMINUM ALLOYS CAN RESIST corrosion in either marine or inland atmosphere for at least 20 years. Also evaluated in the long range studies were a number of protective coatings some of which gave complete protection for the entire period.

NYLON CEMENT THAT REQUIRES NO CURING achieves joints that possess all the strength and inherent characteristics of nylon itself. Bonds are effective under wide temperature ranges and high resistance is noted to oils, aromatics, aliphatic solvents, fruit acids, alkalis, and bleaches.

Materials Outlook

BODY SHELL of an experimental gas turbine automobile was fabricated from titanium. This marks the first time this metal was used in an automobile body.

ELECTRODEPOSITION OF IRON-ZINC ALLOY coatings on steel has been developed. Alloys with a low zinc content of about 6% are hard and can be deposited bright; they could be used as a base for other electro finishes. The alloys show good adhesion to the steel base, and coated sheet or strip can be deformed without damage to the coating. Rates of deposition are high in all cases, particularly the 35% and 65% alloys which can be plated at the rate of 1 mil in 5 min.

CHEMICAL MILLING OF MAGNESIUM is undergoing intensive investigation. A highly efficient etchant is currently being perfected with emphasis on improving control procedures and masking techniques. Acid etchants for steel and titanium alloys are also being studied.

THORIUM, AT $19.50 PER LB, IS BEING OFFERED to industry by the government. Known as the "fertile material", it will be sold to enterprises planning to use it for peacetime purposes.

ISOPHTHALIC, A PETROCHEMICAL, which imparts improved properties to plastics, will soon be available in commercial quantities. Tests indicate that various plastics when "alloyed" with isophthalic are tougher, have greater impact resistance, and give a better gloss in the finish.

BB GUNS ARE USED TO TEST the effect of small particles sucked into the front end of jet engines. In the laboratory, small bb's are fired at blade samples to simulate the effect of small stones.

BRAZING UNDER HIGH VACUUM, in an atmosphere free of oxidizing gasses, produces a superior product, with greater strength, ductility, and uniformity. Peel tests show that vacuum brazing of stainless steel to nickel-base alloy produced tough, ductile joints which were estimated to be more ductile than those obtained by brazing in normal atmosphere.

A YEAR'S PRODUCTION OF VINYL PLASTIC PRODUCTS in one month is possible with automatic electronic welding equipment with only supervisory operators in attendance. The rapid trend toward automatic welding of plastics, currently used by 25 different types of industries, calls for bigger, and sturdier presses to replace the smaller capacity machines.

MAGNETIC PARTICLE INSPECTION using water as a solvent has been developed. Advantages of the method, compared to the conventional petroleum base method of magnetic particle inspection, include: virtual elimination of a fire hazard, the solvent used is not irritating to the skin, equivalent sensitivity in detecting defects, and reduced cost.

Materials BRIEFS

Hot Stuff

Insulating wool has been made from Mt. Etna lava. Claimed to withstand greater heat than most glass fibers, the volcanic wool is being studied for possible jet plane applications.

Bluebird Anatomy

Aluminum was there when the Bluebird piloted by Donald Campbell set a new world speed record of 202.32 mph on July 23. The turbojet hydroplane has an outer skin of aluminum alloy (N4 and N5) sheets, 18 and 16 S. W. G.

Cat Eye

Developed by the Airforce, an electronic optical amplifier can see in the dark with daylight clarity. Utilizing a cathode ray tube image, it is a thousand times more sensitive than a TV camera.

Plastic Satellite

Containing shell for the earth satellite will probably be plastic. Metal would tend to shield signals emitted and inhibit instrument measurements of space phenomena.

Sky Platform

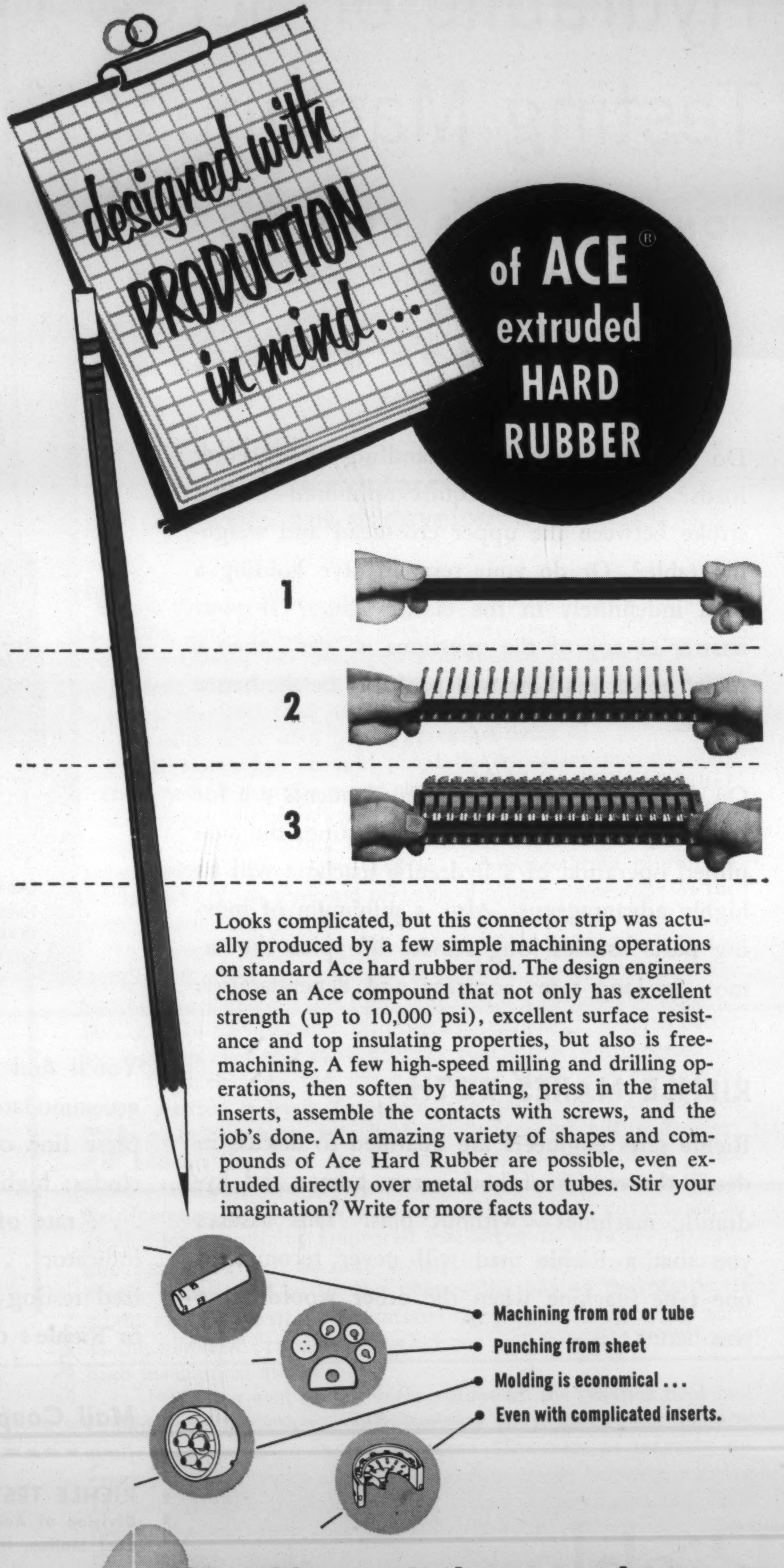
Rising 70 ft into the air, an aerial work platform will make expensive scaffolding obsolete. Built to accommodate four workmen, the lift can carry a load of 1500 lb.

Steel Spectacular

During the Christmas season, floodlights totaling 10 billion candlepower illuminated the Socony Mobil stainless steel building in Manhattan. Across the way the 27 year old Chrysler Building bathed in reflected glory.

Packaged Education

As a quick and economical means of alleviating the critical shortage of schools, architects and school board officials are starting to purchase packaged steel buildings for gymnasiums and classrooms.


designed with PRODUCTION in mind...
of ACE® extruded HARD RUBBER
1
2
3
Machining from rod or tube
Punching from sheet
Molding is economical . . .
Even with complicated inserts.

Looks complicated, but this connector strip was actually produced by a few simple machining operations on standard Ace hard rubber rod. The design engineers chose an Ace compound that not only has excellent strength (up to 10,000 psi), excellent surface resistance and top insulating properties, but also is free-machining. A few high-speed milling and drilling operations, then soften by heating, press in the metal inserts, assemble the contacts with screws, and the job's done. An amazing variety of shapes and compounds of Ace Hard Rubber are possible, even extruded directly over metal rods or tubes. Stir your imagination? Write for more facts today.

ACE rubber and plastic products

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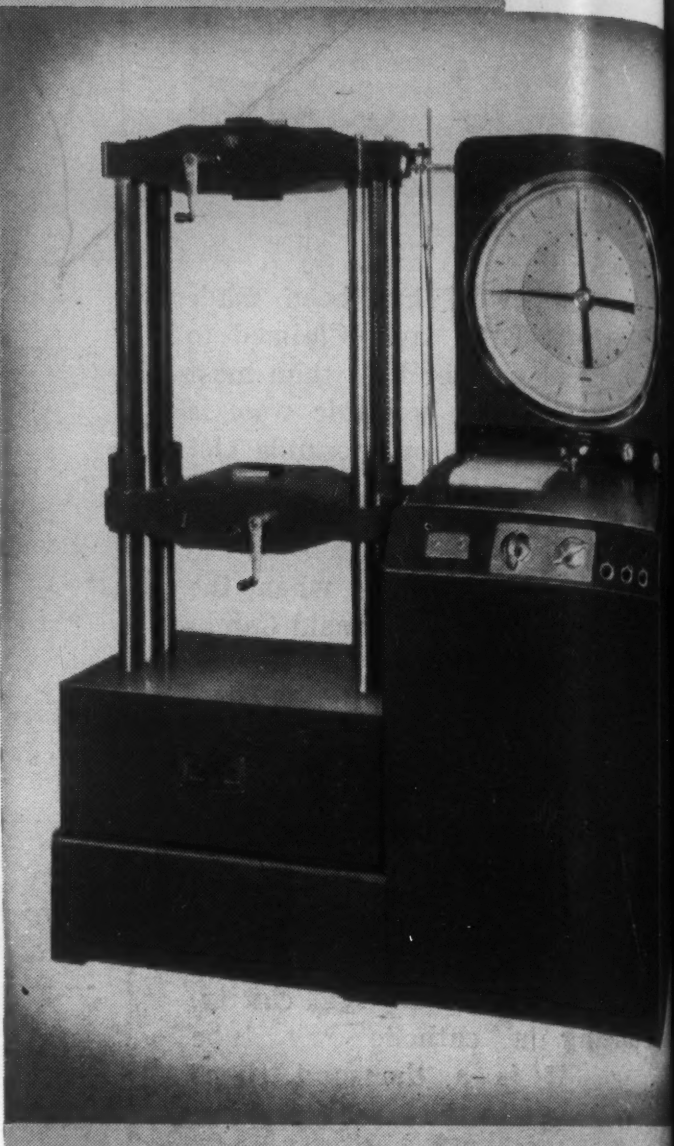
Hydraulic or Screw Power Testing Machines?

ONE MAY BE BETTER FOR YOUR PARTICULAR TESTS



Screw power universal testing machine, 60,000 p capacity. Riehle offers both screw power and draulic machines, recommending whichever is appropriate for the tests to be performed.

Do your tests require the handling of off-center loads? Do your tests require unlimited loading stroke between the upper crosshead and weighing table? Or do your tests involve holding a load indefinitely in the elastic range? If your answer to any of the questions is "yes", then a screw power machine will probably be the better choice.

On the other hand, if your requirements are for regular production and control testing, the simplified operation of a hydraulic machine will be highly advantageous. Also, a minimum of moving parts assures long service life plus the utmost in long term accuracy and dependability.

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Riehle sales engineers are qualified to discuss in detail the merits of both screw power and hydraulic machines — without bias. This assures you that a Riehle man will never recommend one type machine when the other would serve you better.

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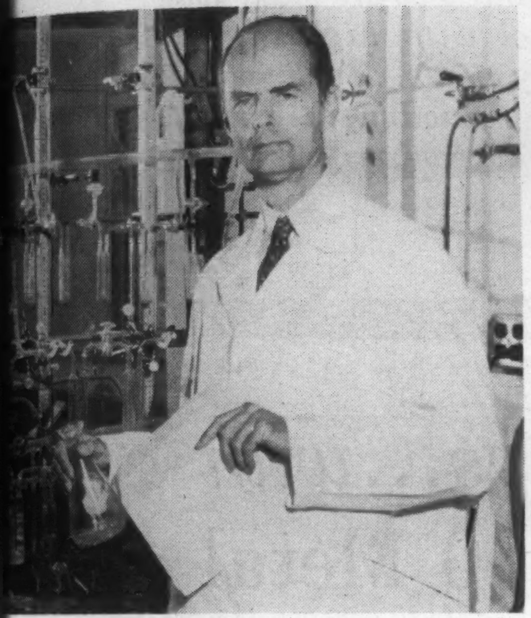
Men of Materials...

Bjorksten says:

"Non-glass reinforced plastics is a fertile but undeveloped field."



Johan Bjorksten, Founder and President of Bjorksten Research Laboratories, received his PhD from the University of Helsingfors, Finland. After varied experience in industry which included research chemist for Felton Chemical Co., in charge of development for Pepsodent Co., chief chemist for Ditto, Inc., and chemical director of Quaker Chemical Products Co., he founded Bjorksten Research Laboratories in December, 1944. He was also a co-founder of A-B-C Packaging Machine Corp. in 1940 (vice president 1943 to date) and of Bee Chemical Co. in 1944 (president 1944-46, chairman of board 1946 to date).

"Glass fiber was not widely used for reinforcing plastics until the 1940's, but it has rapidly gained preference over other reinforcing materials. The most powerful factors in bringing about the present wide acceptance of glass for reinforcing plastics are the research effort that has gone into solving related problems and the sales drive of a few agggressive firms.

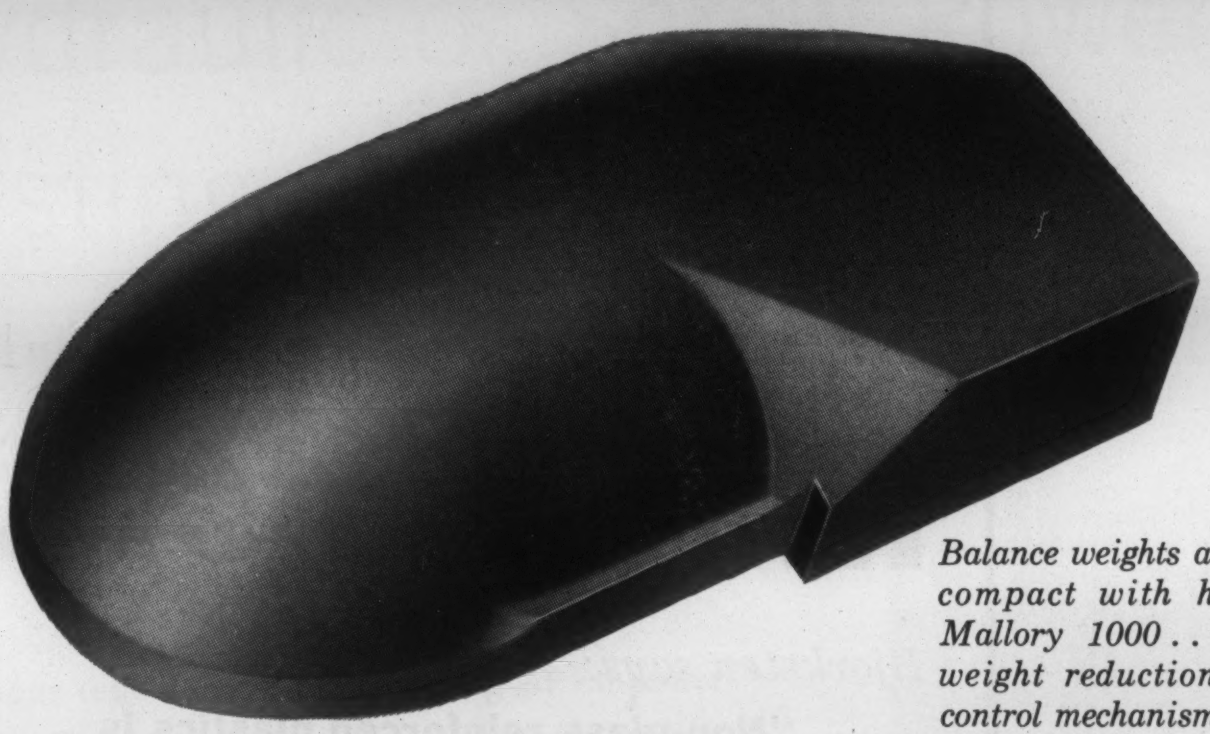
"Research has brought about the necessary modifications of fibers and fiber surfaces and contributed to the development of sizes, finishes, and application methods. But the extent of the economic drive promoting the adoption of glass reinforcement is evident when we consider that in a representative reinforced article, 75% of the cost and probably a higher percentage of the profit on raw materials stem from the glass reinforcement.

"If a similar strong financial incentive and a concentrated research effort had led someone to promote any one of the other possible reinforcing substances, we would undoubtedly have today, in addition to glass reinforcement technology, a much better developed market and know-how for that other reinforcement.

"For example, the newer synthetic fibers have advantages which provide a basis for promoting their use with plastics. While glass fiber has a very high tensile strength but is also very stiff and brittle, there are a number of synthetic fibers which possess relatively high strength and are less stiff and more tough. Reinforcement of plastics with these fibers offers advantages in applications requiring improved resistance to abrasion, erosion and flexing as well as high strength. By matching the stress-strain characteristics of the fiber with that of the plastic, it might also be possible to reinforce thermoplastic materials such as the new low pressure polyethylenes and thus impart to them high mechanical strength.

"We are still at the early stages of the plastics field and cannot look for other reinforcements to replace glass on any really large scale in the near future. However, as markets increase, the technology of synthetic fibers, which has been lagging far behind that of glass fiber, is bound to catch up, and their peculiar advantages find increasingly wide application. When that happens, new applications will be brought into the range of general plastics technology to the benefit of all."

P.R. MALLORY & CO. Inc.
MALLORY



Balance weights are made more compact with high density Mallory 1000 . . . with overall weight reduction in aircraft control mechanisms and similar devices.

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SAVING weight by using a *heavier* metal is not as contradictory as it seems at first glance. Here is how Mallory 1000 Metal can help you do this.

With its exceptionally high density of 16.96 gm/cc, Mallory 1000 makes it possible to reduce the physical size of counterbalances, balance weights and similar "mass components". Shrinking the size of these units often allows you to cut the dimensions of housings, linkages and other structural elements . . . and thus effect substantial savings in overall weight of the assembly.

Of particular interest to designers is the exceptional uniformity of characteristics offered by Mallory 1000. Its density, tensile strength, modulus of rupture and elongation are held to accurate limits. You can base your calculations on *actual* rather than vague "typical" properties. It leads all other high density metals in its adherence to firm specifications . . . and it offers a combination of weight, strength and machinability that has no equal.

We invite you to investigate the characteristics of Mallory 1000 for any use you have which requires concentrated mass or inertia, in balance weights or rotating elements. Write today to Mallory for complete technical data.

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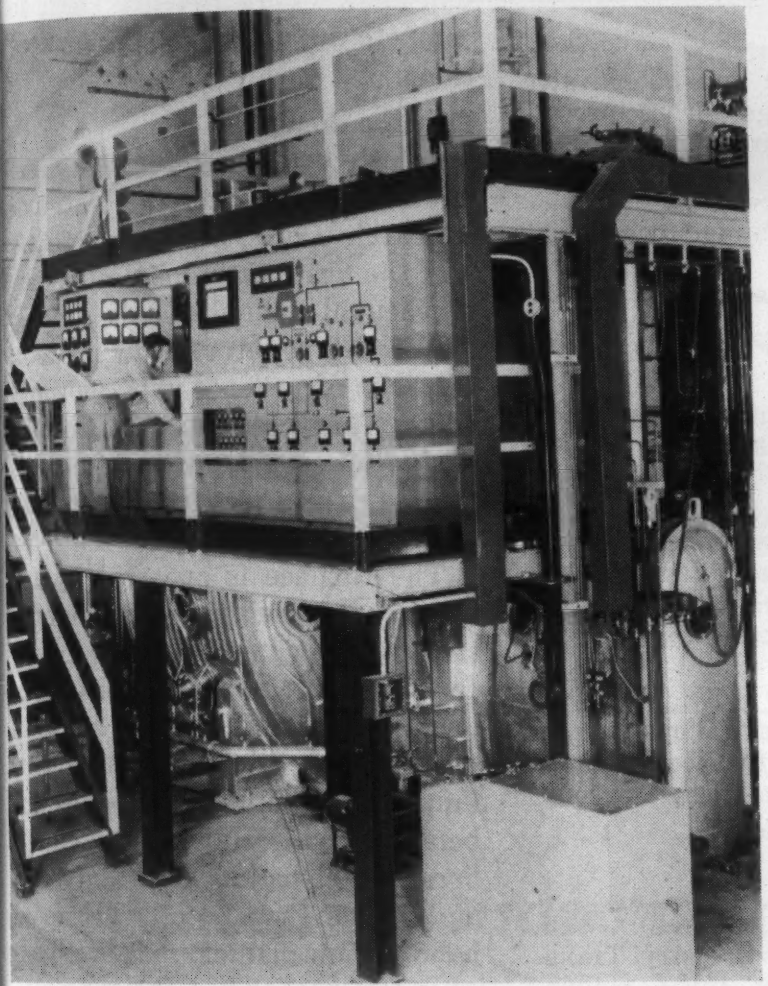
For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

For more information, turn to Reader Service Card, Circle No. 319

MATERIALS ENGINEERING NEWS

Vacuum Melting Furnace
Expanded Research
Materials Outlook '56
Inflated Strip
Corrosion Meeting
Coatings Symposium



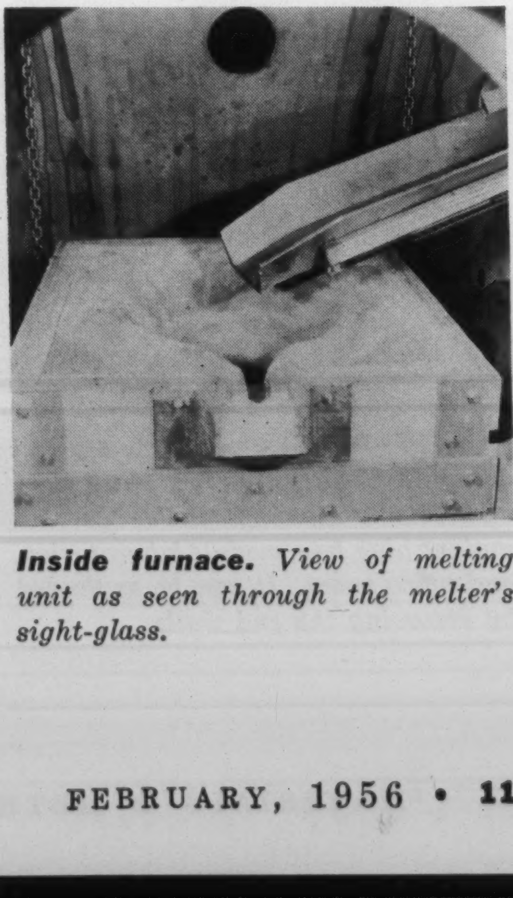
Furnace control. *Melter controls complete melting cycle of vacuum furnace from remote control panel.*

Bearing steel ingot. *A 2200-lb ingot is stripped after removal from vacuum chamber through the air lock.*

Vacuum Metals Corp. Taps 2200-Lb Melting Furnace

Adding its share to the growth of specialty steels, Vacuum Metals Corp. recently tapped the country's largest vacuum melting furnace to date, a 2200-lb capacity unit, at Syracuse, N.Y. Heat sizes up to 2200 lb now offer consumers an increased range of use in larger equipment applications. The new unit increases the supply of specialty steels by 60 to 75 tons per month.

Major use of vacuum melted steels continues to be in the aircraft field where part performance outweighs materials cost. Vacuum melted 52100 grade steel sells for approximately $2.15 per lb while



Inside furnace. *View of melting unit as seen through the melter's sight-glass.*

the same grade air melted is 25¢ per lb. However, James H. Moore, general manager of Vacuum Metals, points out that the gap between costs tends to narrow when all factors are considered. For example, part rejects after using vacuum melted steel have been drastically reduced by one manufacturer, and when used in thrust bearings for jet aircraft, bearing life was increased over six times. In his opinion this type of economy will allow vacuum melted steels to compete in critical area applications.

Furnace design

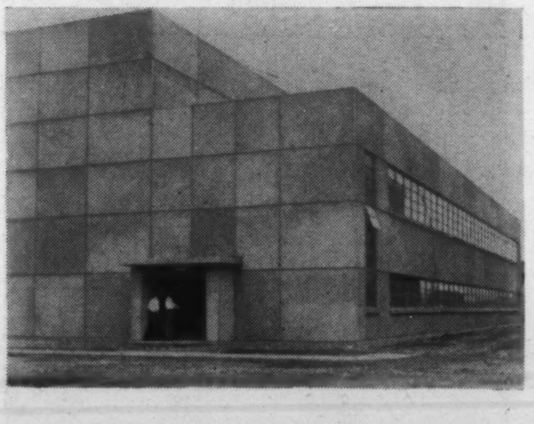
Jointly owned by Crucible Steel Co. of America and the National Research Corp., Vacuum Metals was the first commercial producer of vacuum melted metals and alloys in this country. Drawing upon previous experience with 300- and 600-lb furnaces, the new furnace design was developed under the direction of M. W. Hnilicka of National Research Corp.

The furnace is operated by remote control with the melter controlling the charging, mold transfer, and pouring operations from one console. The melting unit is enclosed in a ¾-in. thick air tight, liquid cooled, stainless steel chamber with connecting air lock chambers for charging raw materials and discharging ingots. The mold handling mechanism makes it possible to cast ingots to varying size and shape, either singly or in multiples from a single heat.

SOME VACUUM MELTED METALS APPLICATIONS

GRADE	TYPE	IMPROVED CHARACTERISTICS	APPLICATIONS
52100	Chrome - carbon bearing steel.	Cleaner, lower nonmetallics, higher fatigue strength. Better surface finish. Lower frictional torque. Better yield in production of bearings.	Inner and outer races for instrument bearings. Thrust bearings for main shaft in jet engines. Rolls for rolling thin metal strips.
A-286 Discalloy	Fe base. Precipitation hardening. Higher temperature alloys.	Higher hot stress rupture. Better transverse ductility.	Wheels for turbo-jet engines.
6150	Cr-V spring steel.	Higher endurance limit. Lower nonmetallic inclusions.	Inner and outer valve springs for reciprocating aircraft engines.
4340	Cr-Ni-Mo-high strength alloy steel.	Higher endurance limit. Higher notch tensile at high strengths. Low susceptibility to hydrogen embrittlement. Higher transverse ductility.	Airframe component parts that are heavily stressed, i.e., landing gears, bolting, etc.
1020	Low carbon steel.	Low nonmetallic inclusions. Gas content and high vapor.	Vacuum tires in electronics industry.
Nickel	Base metal.	Higher purity. Lower gas content. Low content of high vapor pressure elements. Lower nonmetallic content.	Vacuum tubes for electronics industry. Hydrogen thyratrons. Magnetrons, etc.
Iron	Base metal.	Higher purity. Lower gas content. Lower nonmetallics and low content of high vapor pressure elements.	Magnetic alloys, vaccum tubes for electronics industry. Magnetrons klystrons, etc.
Copper	Base metal.	Higher purity, lower gas content. Lower nonmetallics and low content of high vapor pressure elements.	Vacuum tubes in electronics industry. Transmitting tubes magnetrons, klystrons, etc.

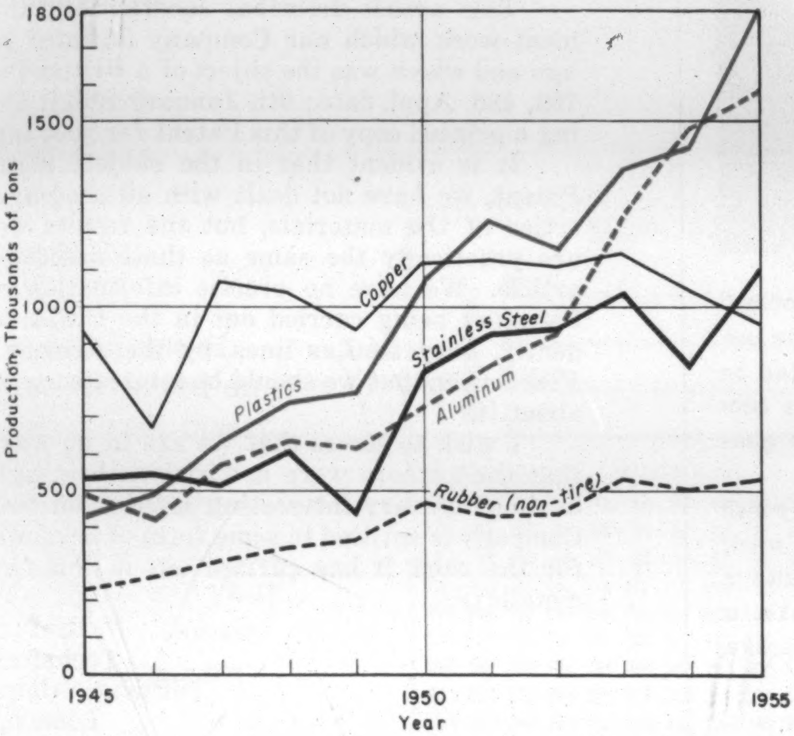
Expanded Research Facilities



Chemical engineering building *of Electro Metallurgical Co. contains a giant high bay, module laboratories, and office space. It can be expanded by removing the end walls.*

Electro Metallurgical Co., UCC, has completed its Chemical Engineering Building at Niagara Falls. The module design of the laboratories allows flexibility of arrangement. Removable partitions make it possible to partition office space as needed or to combine two or more laboratories when a larger area is required.

Primary work will be on high purity metals. Electric furnaces for carbiding, hydriding, nitriding, and sulfiding from a gram scale up to a 100 lb scale were built at the laboratories. Two controlled atmosphere or high vacuum furnaces of original design provide temperatures of 1200 and 1500 C respectively. Other equipment includes a 50 kw high frequency induction furnace, vacuum and inert gas arc-melting furnaces, a 500 ton compacting press, and a foil mill capable of reducing a 2 x 6 in. slab to 1 mil foil.



Significant growth. *Versatile products similar to polyester film (top left) contributed to plastics industry boom (E. I. du Pont de Nemours & Co.). Graph (bottom left) shows U. S. production of selected materials from 1945 to 1955. Aluminum sheet (top right) dramatizes continuing expansion of aluminum industry (Aluminum Co. of America).*

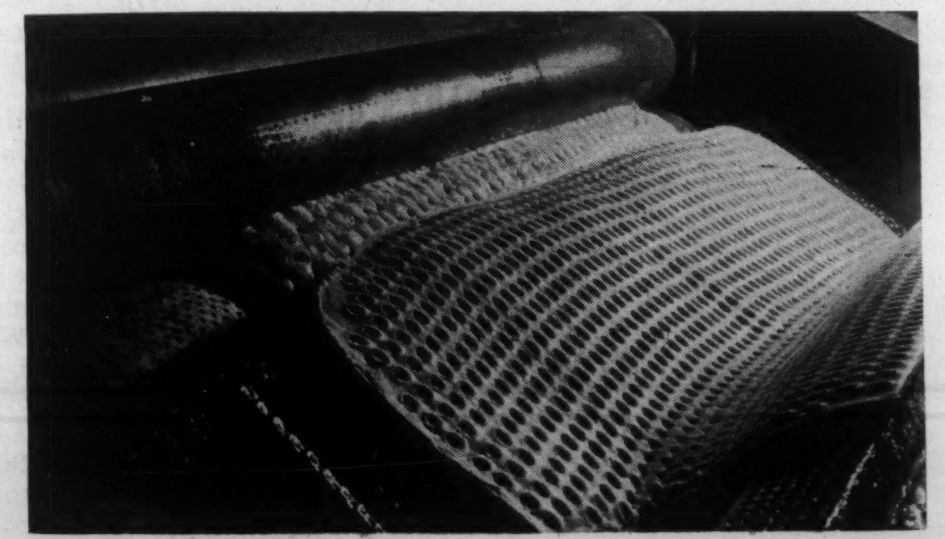
Materials Outlook for '56—Industry Optimistic

Plastics soar . . . Steel to ease . . . Rubber synthetics take over . . . Structural adhesive use up . . . Nickel still a problem . . . Titanium merry-go-round . . . Aluminum out for more . . . Copper set for rebound

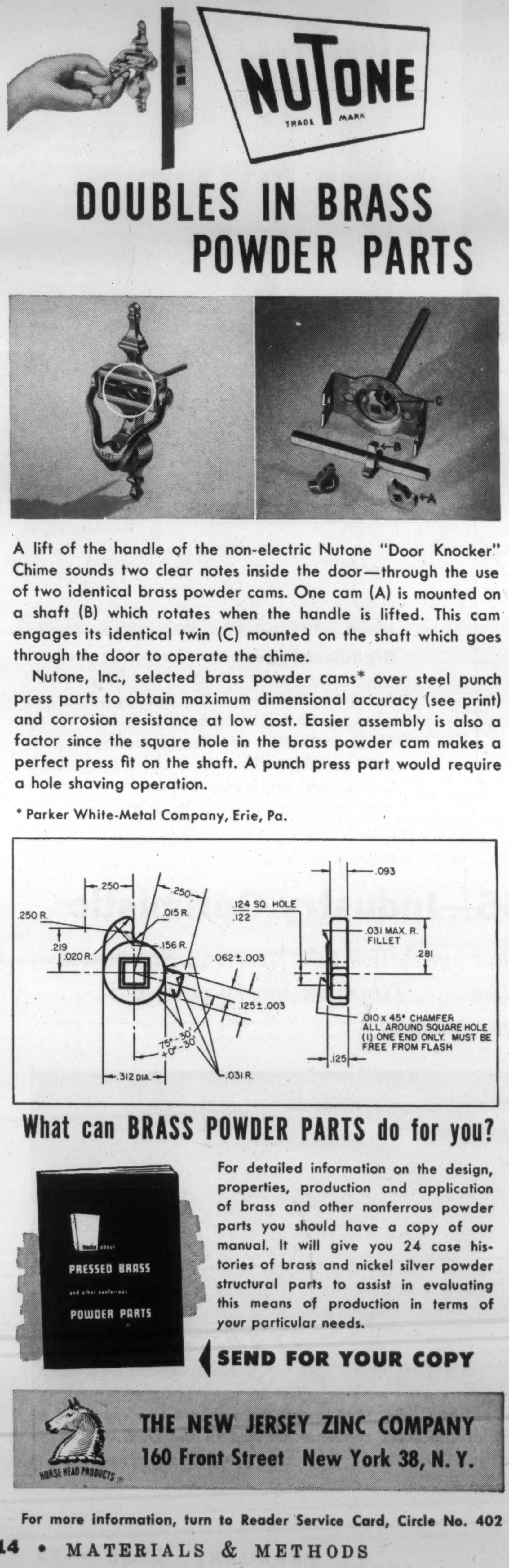
Engineers and product designers ended up 1955 confronted with a materials dilemma. On one side are the rumblings of price increases and on the other the continuing tight supply or outright shortages of key materials.

Forecasts for the first six months of 1956 indicate a continuance if not aggravation of this dilemma. However, industry seers predict some relaxation during the latter half of the year as automotive production continues to slacken and new capacity expansions are brought into play.

(Continued on p. 224)



Synthetic rubber. *By 1960, synthetic rubbers are expected to supply 94% of the total rubber consumed in the U. S.*



DOUBLES IN BRASS POWDER PARTS

A lift of the handle of the non-electric Nutone "Door Knocker" Chime sounds two clear notes inside the door—through the use of two identical brass powder cams. One cam (A) is mounted on a shaft (B) which rotates when the handle is lifted. This cam engages its identical twin (C) mounted on the shaft which goes through the door to operate the chime.

Nutone, Inc., selected brass powder cams* over steel punch press parts to obtain maximum dimensional accuracy (see print) and corrosion resistance at low cost. Easier assembly is also a factor since the square hole in the brass powder cam makes a perfect press fit on the shaft. A punch press part would require a hole shaving operation.

* Parker White-Metal Company, Erie, Pa.

What can BRASS POWDER PARTS do for you?

For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 24 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of your particular needs.

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LETTERS TO THE EDITOR

Pertinent patent

To the Editor:

I was most interested and somewhat surprised, to read in your November last issue an article entitled "Fiber Metals, A New Metal Form" by A. G. Metcalfe and C. H. Sump of the Armour Research Foundation.

This article describes substantially the development work which our Company initiated some years ago and which was the object of a British Patent (No. 706, 486. Appl. date: 9th January 1951). I am enclosing a printed copy of this Patent for your information.

It is evident that in the subject matter of the Patent, we have not dealt with all the physical properties of the materials, but the results we obtained are practically the same as those described in your article. We have no precise information relating to the work being carried out in the U.S.A. along, evidently, very similar lines, by the Armour Research Foundation, but we should be interested to learn more about it.

I wish to stress that we are in no way implying that the authors were not within their right in publishing this very interesting article, but feel that our Company is entitled to some form of acknowledgement for the work it has carried out in this new field of metallurgy.

R. L. Samuel
Technical Director
Diffusion Alloys Limited
London, England

Corrosion debate

To the Editor:

I have just had a chance to read the article on "Corrosion: How It Affects Materials Selection and Design" by Russell W. Henke.

I regret to say that, based on my experience and in my opinion, there are several errors in the corrosion charts as related to stainless steel. Most obvious of these is in the matter of nitric acid, in which case the stainless steel shown is only fair while cupro-nickel is shown as excellent in corrosion resistance.

Also, looking at the second and third items in the table, that is, acetic acid and acetic anhydride, indicates a failure of the tabular information to follow the normally accepted pattern of corrosion resistance of the stainless steels. In each of these cases, corrosion resistance of Type 304 is shown as somewhat less than that of Types 302 and 303. This is almost never the case in stainless steel applications. While available data on Type 308 is relatively scarce, I would expect from its higher alloy content that its over-all corrosion resistance would be higher than Types 302, 303 or 304. Yet you show an unsatisfactory rating for Type 308 on these two grades. In the case of the acetic anhydride, I doubt that corrosion resistance of Type 430 would be better than Types 304 and 308, based on other data I have seen; and while I have seen no data for Type 440 in this application, I certainly question its excellent rating. I also question the excellent rating for Types 410 and 430 in acetone.

(Continued on p. 254)

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PLEASE NOTE: Because of the large quantity of literature reviews this month, some numbers on reply card normally reserved for advertisements are being used to identify Manufacturers' Literature items.

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Students and foreign subscribers (other than Canadian); please request literature directly from manufacturers.

This card not good after April 1.

MANUFACTURERS' LITERATURE

TRADE SHOWS

DESIGN ENGINEERING SHOW. Clapp & Poliak, Inc. Literature, for both visitors and exhibitors, describing the Design Engineering Show—to be held in Philadelphia, May 14 to 17—as well as free admission tickets for visitors. (1)

METAL POWDER SHOW. Metal Powder Association. Literature for both visitors and exhibitors describing the Metal Powder Show—to be held in Cleveland, April 10 to 12. Free admission tickets. (2)

PLASTICS SHOW & CONFERENCE. Society of the Plastics Industry, Inc. Literature describing National Plastics Exposition and concurrent Plastics Industry Conference—to be held in New York City, June 11 to 15. (3)

New Literature

Nickel Plated Steel. The Colorado Fuel & Iron Corp., 12 pp. Manual presents description of electro-clad nickel-plated products covering manufacturing techniques and fabrication procedures. (5)

Plastic Film. Film Dept., E. I. Du Pont de Nemours & Co., 8 pp, illus. Latest commercial uses and detailed physical and chemical properties of Mylar. (6)

Plastics. Plastics Dept., General Electric Co., 8 pp, illus. Entitled "The Plastics Story," brochure gives examples of use of plastics and descriptive and engineering information in tabular form. (7)

Polyamide Resin. General Mills, Inc., 6 pp, No. 11-5-1. Information on polyamide resin suspensoids and their uses. (8)

Glass Reinforced Plastic. The Glastic Corp., 2 pp. Data on fiber glass reinforced polyester laminate sheets. (9)

Aluminum Products. Harvey Aluminum, 8 pp, illus. Describes wrought aluminum products and gives engineering and design data. (10)

Laminated Plastics. Haskelite Mfg. Corp., 8 pp, illus. Data on plastic laminated sandwich panels in a range of sizes and thicknesses. (11)

Carbon and Rubber Products. Henrite Products Corp., 32 pp, illus. Gives information and data on typical company products in carbon and rubber fields. (12)

Copper Clad Steel. Joseph Kinney Co., Inc., 30 pp, illus. Lists new uses for clad metals and presents technical information and drawings on applications. (13)

Aluminum Bronze Alloys. W W Alloys, Inc., 32 pp, illus. Basic information on composition and functions of aluminum bronze alloys in castings and includes specifications and machining recommendations. (14)

Electrical Steels. Allegheny Ludlum Steel Corp., 28 pp, No. EM 21. Data on electrical sheets and strip, gage, performance guarantees, and graphs on technical aspects. (15)

Protective Coatings. Amercoat Corp., 4 pp, illus. Describes protective coating systems that incorporate corrosion resistance into a project. (16)

Molding Compound. American Cyanamid Co., 6 pp. Technical data on glass fiber filled melamine-formaldehyde molding material. (17)

Coating Resins. Barrett Div., Allied Chemical & Dye Corp., 12 pp, illus. Properties of Plaskon urea and melamine coating resins for baking enamel systems is presented. (19)

Stainless Fasteners. Allmetal Screw Products Co., Inc., 52 pp, illus. In-

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dexed reference for 40 basic fastening devices, including engineering data on properties. (20)

Chromium Diffusion Kit. Alloy Surfaces Co. Laboratory test kit containing instructions and materials required to diffuse chromium into small pieces of steel to give the surface characteristics of stainless steel. (21)

Pressure Lubricants. The Alpha Molykote Corp., 4 pp, illus, No. 103A. Describes industrial applications of Molykote lubricants with table of temperature ranges. (22)

Plastic Pipe. Alpha Plastics Inc., 10 pp, illus. Applications, sizes, properties, and fittings of PVC corrosion resistant pipe. (23)

Stainless Steel Fastenings. Anti-Corrosive Metal Products Co., Inc., 64 pp. Catalogs over 9,000 stainless steel fastenings and gives price lists and discount sheets. (24)

Pre-finished Metals. Apollo Metal Works, 8 pp, illus. Describes variety of pre-finishing work on metals for special design and fabricating problems. (25)

Hardness Chart. The Babcock & Wilcox Co. Chart shows relation between hardness by various testing systems and tensile strength of carbon and alloy steels. (26)

Monofilament Extrusion. Bakelite Co., 14 pp, illus. Reports investigation on processes and equipment to produce plastic monofilaments of high commercial quality. (27)

Conversion Tables. Barber-Colman Co., 14 pp, No. F7255. Thermocouple temperature-millivolt equivalents expressed on the International Temperature Scale of 1948. (28)

Beryllium Copper. The Beryllium Corp., 2 pp, illus. Use of a long run beryllium copper plunger tip on a die casting machine. (29)

Plating and Anodizing. Carl Buck & Associates, 4 pp, illus. Data on heat exchangers for all plating, pickling, and anodizing solutions. (30)

Parts Comparison. Caterpillar Tractor Co. Booklet compares parts available from machine manufacturer to those offered by substitute parts manufacturers. (31)

Foundry Alloys. Cerro de Pasco Corp., 12 pp, illus. Reference file on foundry and pattern shop techniques. (32)

Metal Cleaning. Circo Equipment Co. Series of bulletins on ultrasonic degreasing equipment and systems for cleaning metal parts. (33)

Color Calibration. Claremont Pigment Dispersion Corp., 10 pp, No. 175. Complete information on a range of calibrated color pastes for vinyl compounding. (34)

Vacuum-Forming. Coating Products, 2 pp, illus. Bulletin on vacuum forming method of molding thermoplastic sheets. (35)

Plastic Pipe. Corning Glass Works, 12 pp, illus. Physical properties, uses, and specified dimensions of PVC pipe and fittings. (36)

Extrusions and Castings. Metals Processing Div., Curtiss-Wright Corp., 2 bulletins, 8 pp each, illus. Bulletins describe method of extruding metals and the technique of casting top quality parts. (37)

Precision Castings. Midwest Foundry Div., L. A. Darling Co., 8 pp, illus. Describes casting facilities for aircraft, ordnance, machine tool, appliance industries, and for custom castings to specifications. (38)

Metal Stampings. Dayton Rogers Mfg. Co., 8 pp, illus. Metal stamping parts available, cost data, and facts regarding company's services are given. (39)

Silicone Reference Guide. Dow Corning Corp., 12 pp, illus. Describes 150 silicone products grouped by physical form and cross-indexed by usage. (40)

Forging Information. Drop Forging Assn., 8 pp, illus. Booklet describes what forging is and uses of method in everyday products. (41)

Metalworking Tools. The Eaton Co., 34 pp, illus. Describes representative gear production machines and tools. (42)

Investment Casting. Eco Engineering Co., 4 pp, illus. Investment casting method explains using a stainless steel pump impeller as an example. (43)

Paper Base Laminates. The Formica Co., 4 pp, illus. Physical data and uses of Formica XXXP-36. (44)

Electrical Materials. Gibson Electric Co., 6 pp, illus. Specifications of electrical contact materials including silver, paladium, nickel, and powdered metal compositions. (45)

Paint Finish for Metal. The Glidden Co., 20 pp, illus. Displays application of Nubelite, an industrial paint finish for any metal product. (46)

Oil Resistant Rubber. The Goodyear Tire & Rubber Co., Inc., 1 p. Data sheet on Chemigum N3, a butadiene-acrylonitrile copolymer, for use with aromatic fuels or gasoline. (47)

Zinc Die Castings. Gries Reproducer Corp., 8 pp, illus. Design information and properties of zinc alloys for die casting. (48)

Special Metal Processing. Hamilton Watch Co., 16 pp, illus. Outlines service available for production of made-to-order metals in experimental quantities. (49)

Nickel Plating. Hanson-Van Winkle-Munning Co., 16 pp, illus. Describes patented sulfamate nickel plating process and presents graphs on temperatures and current densities. (50)

Heat Treating. Holcroft & Co., illus. Series of data sheets on furnace design, production, and general heat treating information. (51)

Ring Packings. E. F. Houghton & Co., 8 pp. Engineering and design data for Vix-Syn "O" ring packings used in sealing of hydraulic and pneumatic equipment. (52)

Bronzes. The International Nickel Co., Inc., 28 pp, illus. Engineering properties and applications of Ni-Vee bronzes with tables and graphs. (53)

Centrifugal Castings. Janney Cylinder Co., 8 pp, illus. Lists advantages of centrifugal castings of stainless steel alloys for finished machine products. (54)

Metals and Alloys. Kawecki Chemical Co. Technical data sheets and production list of metals and alloys produced. (55)

Aluminum Hand Forgings. Kaiser Aluminum & Chemical Corp., 6 pp, illus. Minimum mechanical property guarantees for all classes of hand forgings are charted. (56)

Fluorocarbon Polymers. Chemical Mfg. Div., The M. W. Kellogg Co., 6 pp. Physical, electrical, chemical, and mechanical properties of Kel-F plastic. (57)

Steel Bar. La Salle Steel Co., 20 pp, illus. Data and charts on properties of a high strength, free machining bar. (58)

Red Lead. Lead Industries Assn., 4 pp, No. 10. Data on red lead alkyd vehicle primer for industrial and marine environments. (59)

Radiography. Metal & Thermit Corp., 4 pp, illus. Industrial radiography with gamma rays for field and shop work. (60)

Metal Processing. Metallurgical, Inc., 12 pp, illus. Surveys facilities of company and services available. (61)

Honing. Micromatic Hone Corp., 31 pp, illus. Kinds of surface finishes, services and equipment available in the honing field. (62)

Adhesives and Sealers. Adhesives & Coatings Div., Minnesota Mining & Mfg. Co., 8 pp, illus. Describes adhesives, coatings, and sealers for the railroad industry and lists 23 typical applications. (63)

Forgings. National Forge & Ordnance Co., 4 pp, illus. Description of company forging facilities. (64)

Industrial Ovens. Newcomb-Detroit Co., 14 pp, illus. Illustrates and gives facts on all types of ovens, heaters, and dryers for a variety of manufacturing processes and materials. (65)

Plastics Forming. Nordic Plastics Co., Inc., 4 pp, illus. Lists thermoplastic materials available for vacuum forming and company facilities. (66)

Lubrication. Parker Rust Proof Co., 12 pp, illus. Parco Lubrite described for reducing wear on bearing surfaces. (67)

Forgings for Autos. Pittsburgh Forgings Co., 4 pp, illus. Pictures forgings made for the automotive industry. (68)

Special Shaped Alloy Wire. Alloy Metal Wire Div., H. K. Porter Co., 4 pp, illus, No. T-2. Describes special shaped alloy wire and tabulates properties. (69)

Polystyrene Patterns. Precision Metalsmiths, Inc., 4 pp. Guide for making polystyrene patterns, describes machining procedures, and gives sources for materials. (70)

Manufacturers' Literature

Aluminum Products. Revere Copper & Brass, Inc., 35 pp, illus. Lists products and applications and includes tables on alloys available. (71)

Rubber Rolls. Rodney Hunt Machine Co., 60 pp, illus. Industrial handbook on rubber rolls with information on manufacture, application, and maintenance. (72)

Roll Formed Shapes. Roll Formed Products Co., 26 pp, illus. Contains drawings and dimensions of 100 complex and simple shapes and reference charts for dimensions. (73)

Casting Aluminum Alloys. The George Sall Metals Co., illus. How to melt and cast aluminum alloys. (74)

Wax Injection Presses. Alexander Saunders & Co., 8 pp, illus. Specifications and prices on wax injection presses for investment casting. (75)

Polyvinyl Chloride. Plastics Div., Seiberling Rubber Co., 2 pp. Data sheet on polyvinyl chloride giving physical data and types available. (76)

Custom Molded Teflon. Sparta Mfg. Co. Brochure illustrates various applications of Teflon as cup, ball or shaft seals, washers, and diaphragms. (77)

Ultrasonic Testing. Sperry Products, Inc., 2 pp, illus. Reflectoscope for ultrasonic nondestructive testing. (78)

Form Coating. Stonhard Co., 6 pp. Gives data on a form coating developed from liquid resin free from fire hazards up to 200 F. (79)

Light Metal Heating. Surface Combustion Corp., 8 pp, illus. Furnaces for the heating and heat treatment of aluminum and other light metal alloys from ingot to finished product. (80)

Welding. The Taylor-Winfield Corp., 4 pp, illus. Cites examples of use of precision welding equipment. (81)

Temperature Conversion Table. Thermo Electric Co., Inc. Conversion table, 8½ x 11, from minus 460 to plus 4000 degrees. (82)

Other Available Literature

Irons and Steels • Parts • Forms

Forgings. ACF Industries, Inc., 26 pp, ill. Describes complete industrial forging service facilities. (86)

Metal Products. Allied Metal Specialties, Inc., 4 pp, illus. Illustrates a variety of trays, racks, fixtures, tanks, crates, baskets, etc. produced by this company. (87)

Stainless Steel. Alloy Tube Div., Carpenter Steel Co., 22 pp, ill. Description of Carpenter Stainless No. 20 and No. 20-Cb sulfuric acid resisting steels. Gives corrosion resistance, applications, working characteristics with listing of forms and shapes available. (88)

Centrifugally Spun Tubes. American Cast Iron Pipe Co., 4 pp, ill. Stock list of company's centrifugally cast tubes furnished as-cast, rough machined or finish machined. (89)

Carbonyl Iron Powder. Antara Chemicals Div. of General Dyestuff Corp., 31 pp, ill. Description, use and formulation of high purity carbonyl iron powders for electronic and powder metallurgy use. (90)

Steel Casting Design. Atlantic Steel Castings Co., illus. Offers detailed in formation on how to economically design steel castings. (91)

Low-Alloy Steel. Bethlehem Steel Co., 66 pp, illus, No. 353. Properties and features of Mayari*R steel for use in applications requiring high strength and good wear and corrosion resistance. (92)

Steel Tubing. Bundy Tubing Corp., ill. Steel tubing for various industrial applications. (93)

Stainless Steel Heads. G. O. Carlson, Inc. Various lists of typical uses and dies available. Price lists included. (94)

Enameled Metal Strip. Coated Coils Corp., 4 pp, ill. Describes coiled enameled metal strip supplied in widths up to 30 in. which can be put through operations without damaging the coating. (95)

Bolt and Forging Products. Columbus Bolt & Forging Co., 40 pp, illus. Describes company's facilities for producing assembly parts for the bolt and forging industries. (96)

Lead Treated Steel. Copperweld Steel Co., Steel Div., 8 pp, illus. Mechanical properties and applications of lead treated steels. (97)

Stainless Steel Tubing and Pipe. Damascus Tube Co., 8 pp, illus. Profusely illustrates the manufacturing process of stainless steel tubing and pipe offered by Damascus. (98)

Steel Fabrication. Delaware Steel Fabricating Corp., 4 pp, ill. Company facilities for steel fabrication and list of representative products. (99)

Custom Steel Parts. H. Disston & Sons, Inc., 16 pp, illus. Describes custom steel parts, how they are made and how to use and order them. (100)

Iron Powder. Easton Metal Powder Co., Inc., 5 pp, illus. Specifications for designing for Ferroflame "A" iron powder. (101)

Alloy Steel Castings. Electric Steel Foundry Co., 10 pp, illus, No. 1. Discusses extra low carbon cast stainless alloys, their chemical composition, typical physical properties and applications. (102)

Metal Stamping. Fred Goat Co., Inc., 18 pp, illus. Specification and application data for varieties of tube shields, clips, caps and rings. (103)

Machine Part Castings. Hunt-Spiller Mfg. Corp., 20 pp, ill. Gun iron castings of 100% pearlitic microstructure. (104)

Stainless Steel Castings. Kolcast Industries, Inc., 4 pp, illus. Large stainless steel precision castings made by the frozen mercury process. (105)

Stampings. Laminated Shim Co., Stampings Div., 12 pp, ill. Describes facilities for producing good quality stampings to specifications, facts to be considered in ordering stampings and other data. (106)

Pressed Parts. Lenape Hydraulic Pressing & Forging Co. Catalog shows numerous parts press formed by this company illustrating the kinds of jobs this firm can perform. (107)

Ductile Iron Castings. Lynchburg Foundry Co., 12 pp, illus. Describes ductile cast iron with detailed description of its properties and suggested applications. (108)

Hammered Steels and Forgings. McInnes Steel Co. Folder on manufacturing facilities for forged and hammer formed steel parts. (109)

Powdered Iron Coil Cores. National Moldite Co., 8 pp, illus. Technical data on electronic properties of powdered iron core materials that can be molded to the desired dimensions. Includes range of working frequencies for each. (110)

Iron Powder. Pyron Corp., 8 pp, No. 1. Technical data sheets on hydrogen reduced and electrolytic iron powders. Sintering data, effect of infiltrants, dimensional stability, strengths, etc., chartered. (111)

Stainless Alloy Steel Castings. Quaker Alloy Castings Co., 4 pp. Reference chart gives specifications, designations, analysis, physical properties and heat treatment for stainless, corrosion and heat resistant alloy steel castings. (112)

Steel Tubing. Rochester Products Div., General Motors, 12 pp, illus, No. 271. Features typical applications of GM tubing made in both single and double walls of steel. (113)

Spun Metal Parts. Roland Teiner Co., Inc., illus, No. 51D. Brochure describes this company's facilities for spinning practically any metal or gage required. (114)

Surface Rolled Patterns in Steel. Sharon Steel Corp., 16 pp, illus. Information on sizes, pattern designs, and applications of pattern-rolled steel. (115)

Spun Metal Parts. Spincraft, Inc., No. 3. Data book on metal spinning and fabricating gives data on process and help in designing for economical production. (116)

Steel Tubing. Summerill Tubing Co. Div., Columbia Steel and Shafting Co., 8 pp, illus. Cold drawn steel tubing for hydraulic applications. (117)

Ferrous Castings. Superior Foundry, Inc., 14 pp, illus. Describes multiple coring, economical methods and facilities for casting various alloys. (118)

Manufacturers' Literature

Malleable and Alloy Iron Castings. Texas Foundries, Inc., 20 pp, illus. Describes foundry facilities and provides case histories of applications of malleable iron. (119)

Steel Forgings. Titusville Forge Div., Struther Wells Corp., 8 pp, illus. Describes facilities for precision forging of parts regardless of size, metal or alloy. Shows numerous parts produced. (120)

Vacuum Melted Alloys. Utica Metals Div., Utica Drop Forge & Tool Corp., 8 pp, illus. Describes facilities for producing and testing vacuum melted alloys. (121)

Precision Metal Stampings. John Volkert Metal Stampings, Inc., 4 pp, illus, No. 1. The first issue of "The Volkert View", a quarterly, features case histories of precision metal stamping. (122)

Steel Strip. Weirton Steel Co., 20 pp, illus. Characteristics of electrolytic zinc-coated sheets and strip, high-tensile steel and high carbon strip cold-rolled spring steel being manufactured by the company. (123)

Flanged and Dished Heads. Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., 130 pp, illus. Comprehensive information and engineering data on C F & I flanged and dished heads, flueholes, handholes, saddles, etc. (124)

Stampings. WLS Stamping Co., 4 pp, illus. Describes high-speed, low-cost stamping process using "speed tooling" method. (125)

Nonferrous Metals • Parts • Forms

Die Castings. Advance Tool & Die Casting Co., 8 pp, illus. Illustrates facilities of this company to produce die castings to specifications. (129)

Brazing Alloys. Alloy Ring Service, Inc., 4 pp. Brazing alloys in the form of rings or fabrications. (130)

Wear Resistant Materials. American Brake Shoe Co., 48 pp, illus. Catalog of representative products; castings, bearing materials, forgings, sintered metals and industrial equipment. (131)

Bronze Casting Alloys. American Manganese Bronze Co., 50 pp, illus. Revised edition gives composition, characteristics and applications of the principal copper alloys used to make castings. (132)

Electrolytic Copper Powders. American Metal Co., Ltd., 3 pp. Data sheets on specifications for electrolytic copper powders. (133)

Precision Castings. Atlantic Casting & Engineering Corp., 12 pp, illus. How to obtain nonferrous castings cast to ordinary machining tolerances. Describes process and gives alloy specifications. (134)

Vacuum Die Casting. Aurora Metal Co., 8 pp, illus. Describes process for aluminum bronze and silicon bronze. Applications, physical and chemical specifications. (135)

Magnesium. Brooks & Perkins, Inc., 8 pp, illus. Describes facilities and services of this company for fabricating magnesium. (136)

Bronze Bar Stock and Bearings. Bunting Brass & Bronze Co., 72 pp, illus, No. 52. A complete presentation of this company's standard stock bearings, graphited oilless bearings, precision bronze bars and electric motor bearings. (95)

Custom and Standard High Alloys. Cannon Muskegon Corp., 4 pp, illus. Ferrous and nonferrous alloys for castings, extrusions and forgings. For remelt or direct use. (138)

Phosnic Bronze. Chase Brass & Copper Co. Bronze alloy for jobs requiring high-strength metal with good conductivity. (139)

Metal Stampings. Crosby Co., 40 pp, illus. Describes company's range of facilities for metal stamping. (140)

Precision Investment Castings. Crucible Steel Co. of America, 16 pp, illus. How to precision cast unmachinable high-temperature alloys to close tolerance through "lost wax" method. (141)

Die Castings. Dollin Corp., 16 pp, illus. Booklet describes plant and facilities for die castings. (142)

Rings. Dresser Mfg. Div., 4 pp, illus. Heavy industrial equipment fabrication from welded rings. (143)

Tantalum Equipment. Fansteel Metallurgical Corp., 28 pp, ill, No. F-1030. Chemical and physical properties of tantalum and its uses in bayonet heaters, coils, heat exchangers and HC1 absorbers. (144)

Stampings. Federal Tool & Mfg. Co., 4 pp, ill. Short run, close tolerance stamping with low cost dies. (145)

Aluminum Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy "40-E", a high strength alloy containing zinc with magnesium, titanium and chromium, which needs no heat treatment. Separate data sheets on specifications, composition and properties. (146)

Thermostat Metal. General Plate Div., Metals & Controls Corp. Information on selecting thermal elements and their design. Tables give major mechanical and physical constants for various thermostatic metals. (147)

Metal Stampings. Geometric Stamping Co., 4 pp, ill. Suggestions for cost savings through conversion from castings to stampings. (148)

Inserts. Groov-Pin Corp. Self tapping insert used as original equipment and for salvage and repair of stripped threads. (149)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 69 and 70

Perforated Materials. Harrington & King Perforating Co., 128 pp, illus, No. 62. Catalog of company's facilities for perforating metals and other sheet and plate materials. (150)

Investment Castings. Hitchiner Mfg. Co., 12 pp, illus. Description of precision investment castings and its advantages and limitations. (151)

Investment Casting. Howard Foundry Co., 8 pp, ill. Description of the new design freedom obtainable through the use of investment castings. (152)

Sheet and Plate Fabrication. Kirk & Blum Mfg. Co., 38 pp, illus. Describes facilities and equipment used in production of metal sheet and plate. (153)

Precision Alloy Moldings. Lebanon Steel Foundry, 2 pp. Announcement of the Ceramicast process utilizing ceramic molds for precision castings adaptable to almost any casting size or alloy. (154)

Die Castings. Lester Castings, Inc., 4 pp, illus. Describes facilities for producing die castings. (155)

Die Castings. Litemetal DiCast, Inc., 12 pp, ill. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (156)

Titanium Alloys. Mallory-Sharon Titanium Corp., 4 pp, illus. Gives physical properties, forging recommendations, etc., for a high tensile strength titanium alloy primarily for bar and forging applications. (157)

Castings. Meehanite Metal Corp. Physical specification chart for engineering design in the form of a calculating wheel. Characteristics of general engineering, heat-resisting, corrosion-resisting and wear-resisting metals. (158)

Metal Powder Parts. Metal Powder Products, Inc., 4 pp, illus. Features a variety of applications for iron, iron-copper and bronze sinterings made by this company. (159)

Nonferrous Castings. Monarch Aluminum Mfg. Co., 4 pp, ill. Describes permanent mold castings made by new process to give high, dense finish of great durability. (160)

Aluminum Core. Narmco Metlbond Co., 6 pp. Formable core material for aluminum sandwich constructions where application requires small radius curves. (161)

Cored Forgings. National Cored Forgings Co., Inc., 8 pp, ill. Advantages and typical examples of cored forgings made of brass, bronze, copper and other nonferrous metals. (162)

Electrolytic Nickel Powder. National Radiator Co., Plastic Metals Div. Specifications Sheets No.'s PMS 30, 31, 32, 33 and 34. Lists chemical and physical properties of five grades of electrolytic nickel powder. (163)

Manufacturers' Literature

Precious Metal Wire. The J. M. Ney Co., 2 pp. Technical data on advantages of using Ney-Oro 6, precious metal wire for pivots in instrument bearings. (164)

Boron Carbide. Norton Co., 16 pp, illus. A handbook on boron carbide, elemental boron, and other stable, boron-rich materials. (165)

Precision Castings. Ohio Precision Castings Inc., 12 pp, ill. Numerous examples of industrial applications of this company's brass, bronze, aluminum and beryllium-copper plaster mold castings. (166)

Small Zinc Die Castings. Page & Hall Mfg. Co., Inc., 4 pp, ill. Zinc die casting process which reduces tool and part cost. Includes brief designs guide. (167)

Die Castings. Paramount Die Castings Co., 4 pp, illus. Describes facilities and services and shows representative aluminum, magnesium and zinc castings. (168)

Die Castings. Parker White Metal Co. Engineering data on die cast component parts. (169)

Copper Tubing. Penn Brass & Copper Co., 6 pp, ill. Features of this company's seamless copper tubing. Includes tables of safe internal working pressures of various tubing sizes. (170)

Aluminum Extrusions. Precision Extrusions, 12 pp, ill. Describes aluminum extrusion process with tables of physical properties and recommended applications. (171)

Bushings. Randall Graphite Bearings, Inc., 12 pp, ill, No. 100. Complete price list of bronze bushings and specially grooved bushings; specifications of bored and solid bronze bars. (172)

Nonferrous Alloys. Riverside Metal Co. A reference and guide to alloy specifications of phosphor bronze, nickel silver, cupro nickel and beryllium copper. (173)

Aluminum and Magnesium Casting. Rolle Mfg. Co., 58 pp, illus. Guide to design and specifications of aluminum and magnesium, sand, permanent mold and die castings. Discusses advantages and disadvantages of casting methods and gives properties of common aluminum magnesium casting alloys. (174)

Investment Castings. Scott Casting & Mfg. Co., 20 pp. Explanation of lost wax process. Limitations, sizes and weights of parts, castable metals and alloys. General information on costs and applications. (175)

Aluminum Castings. Solon Foundry, Inc., 4 pp, ill. Description of company's plant and facilities for producing aluminum castings. (176)

Electroplated Palladium and Platinum. Technic Inc. Data sheet describes physical and electrical properties for both metals. Includes corrosion data, specifications, and thickness requirements. (177)

Super Alloys. Universal-Cyclops Steel Corp., 20 pp, illus. High-strength, corrosion-resistant alloys for gas turbines, turbo-superchargers, rockets and guided missiles. (178)

Stampings. Variety Machine & Stamping Co., 4 pp, illus. Describes plant's facilities for, and variety of stampings. (179)

Castings and Patterns. Wellman Bronze & Aluminum Co., 16 pp, ill, No. 53. Includes facilities of this company for producing a variety of nonferrous castings and wood or metal patterns. (180)

Thermometals and Special Alloys. H. A. Wilson Co., 2655 U. S. Route 22, Union, N. J., 192 pp, price $3.00. New Blue Book on thermostatic bimetals, sintered metals, electrical contact materials, composite and laminated metals and special alloys. Provides design data, graphs formulae and properties and applications of hundreds of materials. Also lists production executives, purchasing agents in the field. Write direct to Wilson on company letterhead.

Nonmetallic Materials • Parts • Forms

Barrel Finishing. The Abbott Ball Co., 8 pp, ill. Describes barrel finishing techniques with a new design tumbling barrel. (184)

Plastic Molding. Ackerman Plastic Molding Div., 4 pp, ill. Long run production of plastic parts by compression of plunger molding. (185)

Plastic Pipe. American Agile Corp., 12 pp. Charts give physical and mechanical properties of polyethylene and polyvinyl chloride pipe and tubing and their chemical resistance to various reagents. (186)

Aluminum Protection. American Chemical Paint Co., 4 pp. How to protect unpainted aluminum with "Alodine" No. 1200, a corrosion-resistant coating providing a durable paint bond. (187)

Fiber Glass Reinforced Plastics. Apex Electrical Mfg. Co., 4 pp, illus. Case histories of custom molded fiber-glass parts featuring pressure vessels. (188)

Gasket Materials. Armstrong Cork Co., 24 pp, ill. Complete data on various cork and rubber gasket materials made to meet government specifications. (189)

Epoxy Resin Adhesives. Armstrong Products Co., 16 pp. Price information and technical data on adhesives having high tensile shear strengths. Information on new line of epoxy resin formulations with low shrinkage and good electrical properties. (190)

Gaskets, Packings, Etc. Auburn Mfg. Co., 3 pp, ill. Discusses the various products produced by this company, including gaskets, packings, washers, spacers, seals, shims and bushings. (191)

Rubber Processing. Automotive Rubber Co., Inc., 12 pp, illus, No. 500. Describes plant's facilities for fabricating and rubber coating special production parts. (192)

Blast Cleaning. Baldwin-Hill Co., 4 pp, illus. Describes mineral shot for blast cleaning that prepares metal surface in one air blast application. (193)

Woven Glass Roving. Bigelow-Sanford Carpet Co., Inc., 2 pp. Describes mechanically bonded glass fabric used in reinforced plastics, and lists advantages. (194)

Protective Coatings. Bisonite Co., Inc., 24 pp, illus. Folder of descriptive data on vinyl, phenolic, rubber, acrylic, silicone, furfuryl-alcohol and specialty coatings. (195)

Phenolic Resins. Borden Co., Chemical Div., 8 pp, illus. Durite phenolic molding compounds, bonding resins, basing resins, and impregnating resins. (196)

Optically Clear Plastics. Cast Optics Corp., 12 pp, ill. Five plastic compositions for optical applications such as windshields, lenses, goggles and instrument covers. (197)

Contact Pressure Laminating Resins. Ciba Co., Inc., 17 pp, No. 1. Technical data on Araldite^{R} contact pressure laminating resins. Includes technical and electrical properties, charts and tables, mold preparation, glass fiber reinforcement, and manufacturing procedures. (198)

Reinforced Fiberglass Parts. Clearfield Plastics, Inc., 22 pp, illus. Discusses company's facilities for producing molded contoured parts. Suggests design and specification techniques. (199)

Vulcanized Fibre. Continental-Diamond Fibre Co., 12 pp, illus, No. DVF-55. Complete physical, chemical and electrical properties and other engineering data for vulcanized fibre parts, sheets, tubes and rods. (200)

Plastic. Crane Packing Co., 12 pp, ill, No. T-103. Complete data on Chemlon packings and gaskets fabricated from the new tetrafluoroethylene resin, Teflon. (201)

Elastomers. E. I. du Pont de Nemours & Co., Inc., Elastomers Div. Introduces "Hypalon", a heat and corrosion resistant elastomer for use as protective coating for rubber, wood and metal, gaskets and packings; tank linings and coated fabrics. (202)

Tetrafluoroethylene Resin Coated Glass Fabrics. E. I. du Pont de Nemours & Co., Fabrics Div., 4 pp. Electrical, mechanical, chemical, thermal, and forming properties of Teflon-glass fabrics as well as toxicity precautions and suggested uses. (203)

Teflon. E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., 60 pp, ill. Definitive handbook on tetrafluoroethyl resins. Thorough treatment of history, characteristics, manufacture, compositions, uses and properties of all grades of resins. Analyzes processing techniques for molding, regular- and ram-extrusion, calendering, casting, dipcoating and impregnation. Charts, graphs and bibliography. (204)

Teflon. Ethylene Chemical Corp., 8 pp, ill. Complete data on a variety of molded and extruded Teflon parts, sheets, rods and tubing. Includes table of properties. (205)

Molding Compounds. Fiberite Corp., 1 p, No. 6. Lists phenolic, melamine and other resin-based molding compounds. (206)

Laminating Materials. Flexfirm Products. A folder with 7 technical bulletins Nos 1, 2, 3, 111, 112, 113, 105 and fabrication instructions for polyester resin impregnated glass cloth mat supplied in dry state ready for layup. (207)

Ceramics. General Ceramics Corp., 4 pp. Selection chart for electrical and mechanical properties of a wide range of ceramics. (208)

Rubber and Plastics Extrusions. General Tire & Rubber Co., 16 pp, No. 786. Contains specifications, performance characteristics, tolerances and properties available in common rubber and plastic compounds. (209)

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pp, ill, No. 108. Describes Graphalloy grades for bushings and electrical uses. Bearing design data included. (210)

Graphite. Graphite Specialties Corp., 4 pp, No. GS 101-1. An impervious graphite, more than 99.5% pure carbon for high temperature parts. Chemical resistance data and physical properties including heat effects to 5700 F are charted. (211)

Plastic Coatings. R. M. Hollingshead Corp., 16 pp, illus. Manual on "cocoon" sprayable vinyl plastic coating with instructions on spraying methods. (212)

Polyester Resins. Hooker Electrochemical Co. Folder of data sheets describing fire-resistant and polyester resins. (213)

Glass Fiber Insulation. LOF Glass Fibers Co., 4 pp, illus. Describes low density, resilient glass fiber insulating material. (214)

Glass. Lancaster Lens Co., 8 pp, ill. Twenty-one case histories of a wide variety of glass part applications. (215)

Glass. Libbey-Owens-Ford Glass Co., 8 pp, ill. Glass in product and engineering design. (216)

Plastic Molding. P. R. Mallory Plastics, Inc., 4 pp, ill. Complete production facilities for large scale production of custom-molded parts from design to finishing and assembly. (217)

Glass and Ceramic Parts. Mansol Ceramics Co., 16 pp, illus. Glass preforms for hermetic seals, adhesives, steatite preform and multiform production facilities. (218)

Hardboards. Masonite Corp., 24 pp, ill, No. 1d/2. Properties and advantages of Preswood and other Masonite hardboards, and their relation to product design. (219)

Manufacturers' Literature

Reinforced Wood. Met-L-Wood Corp., 15 pp, illus, No. 521. Describes combined wood and metal sheets, providing light weight and high strength. (220)

Insulating Material. Mica Insulator Co. Catalog of standard electrical insulating materials. (221)

Fire-Resistant Hydraulic Fluid. Monsanto Chemical Co., 20 pp. Describes hydraulic fluid that reduces fire hazards and has operating qualities of petroleum fluid. (222)

Glass Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Design information for parts to be machined from glass bonded mica. (223)

Cathode Protection. National Carbon Co., 12 pp, ill, No. S-6500. How to mitigate corrosion of underground and submerged metal structures by the application of an impressed current cathodic protection system using graphite anodes. (245)

Plastics Moldings. Nosco Plastics, Inc., 10 pp, illus. Facilities for plastics moldings. (224)

Industrial Tape. Permacel Tape Corp., 5 pp. Tape for electrical use, bonding and sound damping. (225)

Ultrasonic Cleaning. Pioneer-Central Div., Bendix Aviation Corp., 8 pp, illus. Folder describes ultrasonic cleaning process and equipment. (226)

Precision Molded Thermoplastics. Plastic Molded Parts, Inc., 6 pp. Facilities available for Zytel and other thermoplastic precision moldings. (227)

Industrial Tape. Polyken Products, 4 pp. Sixteen pressure-sensitive tape samples with accompanying specifications and properties. Explains basic industrial tape applications. (228)

Nylon Tubing. Polymer Corp., 6 pp, ill. Describes 1000- and 2500-psi pressure tubing that is corrosion resistant and has wide temperature range. (229)

Corrosion Resistant Gasketing. Products Research Co., 5 pp, ill. Features, advantages and specifications of Chromelock corrosion resistant gasketing material. (230)

Teflon. Raybestos Manhattan Inc., 8 pp, ill. Gaskets, rings and irregular shapes, sheets, tubes, rods, tape and packings of Teflon. (231)

Tooling Plastics. Ren-ite Plastics, Inc., 4 pp, illus, No. 1001. Describes dimensionally stable tooling plastic for use in laminating or casting without application of heat or pressure. (232)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 69 and 70

Plastic Foams. Rezolin, Inc., 4 pp, illus, No. 104. Foamable plastic for die cores, filled structures, etc. (233)

Molded Plastics. Richardson Co., 12 pp, illus. Describes types and grades of laminated and molded plastics. Applications given. (234)

Gasket Sheeting. Rogers Corp., 4 pp, ill. Describes a line of asbestos-elastomer material. (235)

Rubber. Roth Rubber Co. Kit containing actual rubber samples with hardness from 5 to 100 Durometer. Accompanied by ASTM specifications and list of uses for each sample. Offer limited to engineers and rubber buyers only. Please request Roth Rubber Sampler No. MM3 on company letterhead from Roth Rubber Co., 1860 So. 54 Ave., Chicago, Ill.

Synthetic Rubber Compounds. Rubber & Plastics Compound Co., Inc., 4 pp, ill. Complete data on Nervastral Seal-Pruf, a synthetic rubber flashing and membrane waterproofing sheet, and Nerva-Plast, a cold-setting waterproofing cement. (236)

Corrosion Inhibiter. Solvay Process Div., Allied Chemical & Dye Corp., 17 pp, illus. Use of sodium nitrite in corrosion prevention. (237)

Parts for Wear Applications. Spaulding Fibre Co., Inc., 4 pp, illus. Shows vulcanized fibre and thermosetting plastics parts for long wear applications. (238)

Steatite Ceramic. Star Porcelain Co., 1 p, No. 600. Standard ways of insulating washers and bushings of steatite for high temperature insulation applications. (239)

Polyurethane Foam. Surface Chemicals Inc., 4 pp. Properties of Isothane foam for thermal insulation and sound control. (240)

Vulcanized Fiber and Laminated Plastics. Taylor Fiber Co., 4 pp. Basic properties of plastic laminates and vulcanized fibrous materials given in convenient tables. (241)

Tetrafluoroethylene. U. S. Gasket Co., No. 300. Tables and descriptive matter on the chemical, electrical, thermal and mechanical properties of Teflon. (242)

Nylon Screws. Weckesser Co., 3 pp, illus. Describes black nylon screws and nuts, use in design problems, and price list for various types. (243)

Felt. Western Felt Works, 28 pp. Discussion of felt, its applications, composition, specifications and testing methods. (244)

Finishes • Cleaning and Finishing

Colloidal Dispersions. Acheson Colloids Co., 4 pp. Revised list of 44 colloidal and semi-colloidal dispersions for operational functions, maintenance, lu-

Manufacturers' Literature

brication, machine design and other industrial applications. Includes eight new dispersions. (248)

Zinc, Cadmium Finishes. Allied Research Products, Inc. Describes Iridite, finishes for zinc and cadmium in chromium-like, olive green, irridescent and other colors. (249)

Cleaning and Finishing Media. Almco Div., Queen Stove Works, Inc., 10 pp, illus. Features and applications of Super-sheen Abrasive Chips and Compounds for barrel finishing and cleaning. Also data on finishing machines. (250)

Protective Coatings. Ceilcote Co., 8 pp, illus, No. C-150. Gives base formulations, chemical properties and adhesion characteristics of seven standard organic coatings. Includes simplified chart for selecting coatings, surface treatment, processes, etc. (251)

Molded and Extruded Rubber. Continental Rubber Works, 8 pp, No. 100. Gives dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (252)

Zinc Phosphate Coatings. Cowles Chemical Co., 4 pp. Properties of amorphous and crystalline non-sludging zinc phosphate coatings. (253)

Aluminum Finishing. Diversey Corp., 4 pp. Lists company's cleaning and finishing equipment for aluminum. (254)

Zinc Phosphate Coatings. Detrex Corp., 8 pp, illus. Phosphate coatings for protection of paint finishes under severe corrosion conditions. (255)

Acid-Proof Coatings. Electrochemical Engineering & Mfg. Co., 8 pp, illus, No. G-53. Describes acid and alkaliproof cements as linings and coatings for floors, tanks, etc. (256)

Wear Resistant Coating. Electrolizing Corp., 16 pp. Detailed data on the Electrolizing Process for increasing the life and efficiency of metal parts subjected to wear, abrasion and corrosion. (257)

Chemical Plating. General American Transportation Corp. Large illustrated folder. Description of Kanigen, a new type of nickel plating process requireing no electrical equipment. (258)

Protective Coatings. Industrial Metal Protectives, Inc., 8 pp, illus, No. Z-853. Zincilate self-protecting anti-corrosion coatings for metal parts and products. (259)

Cleaning Tanks. Kelite Products, Inc., 2 pp, illus, No. 130-357R01. Hot and cold cleaning tanks for immersion cleaning or processing. (260)

Bright Copper Plating. Lea Mfg. Co., 22 pp. Technical manual on plating operations for bright copper coatings. Bath compositions and operating conditions given. (261)

Flame-Plating. Linde Air Products Co., Div. of Union Carbide & Carbon Corp., 15 pp, illus. Outlines flame spray process for depositing thin coatings of tungsten carbide on metal parts for wear resistance. (262)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish, said to resist heat of 500 F without discoloration. (263)

Aluminum-Chromium Paint. Monroe Co., Inc., 4 pp, illus, No. C-54-8. Includes detailed application data on Monco-Alochrom, an aluminum-chromium paint for exterior and interior surfaces of all kinds. (264)

Micropolishing. The Murray-Way Corp. Engineering specifications and auxiliary equipment needed for micropolishing. (265)

Stripper. Northwest Chemical Co., 1 p. A liquid stripper to remove organic finishes from plastics, particularly imperfect articles. (266)

Phosphate Coating. Pennsylvania Salt Mfg. Co., 5 pp, illus. Description of the Fosbond process of phosphate coatings for metal finishing. (267)

Fluorine Resin Coatings. Permolite, Inc., two 4-page bulletins. Fluor-O-Alloy coatings based in trifluorochloroethylene polymer. Includes corrosion resistance data and application data. (268)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Ave., Baltimore, Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead direct from this company.

Polyvinyl Chloride Coatings. Quelcor, Inc., 4 pp, illus, No. 53 A. Polyvinyl chloride coatings fused and flowed on metal for corrosion protection. (269)

Acrylic Emulsion Coatings. Rohm & Haas Co., 5 pp. Describes two acrylic emulsions, Rhoplex X-52 and B-85, possessing unusually hard films. (270)

Ceramic Coatings. Solar Aircraft Co., 8 pp, illus. Uses and properties of Solaramic coatings, a family of proprietary ceramic coatings designed to protect high or low alloy steel fabrications from heat and/or corrosion. (271)

Dry Process Tumbling Barrels. Tumb-L-Matic Inc., No. LS-52. Detailed information on a complete line of LS tumbling barrels for cutting down, deburring, definning, dry burnishing and polishing metal and plastic parts. Includes specifications. (272)

Emulsion Cleaners. Turco Products Inc., 10 pp, ill, 106 Series Technical Sheets. Charts, uses, methods of applications, safety precautions, etc., for seven types of emulsion cleaners. (273)

Porous Chromium Coating. Van der Horst Corp. of America, 12 pp, ill. Describes an oil retaining, wear resistant chromium coating for bearing surfaces, cylinder walls and applications where hard wear and lubrication are factors. (274)

Finishing Forgings. J. H. Williams & Co., 20 pp, ill. Describes company's facilities for all phases of forging, including cleaning and finishing. (275)

Materials and Equipment

Induction Furnaces. Ajax Electrothermic Corp., 8 pp, ill, No. 27-B. Induction furnaces for precision melting, heating forging billets, and heat treating. Includes selector chart for induction heating and melting applications. (279)

Welding Electrode. Alloy Rods Co., 4 pp, ill, No. AR-5. Describes new electrode for welding manganese steel. (280)

Aluminum Welding. Aluminum Co. of America, 176 pp. Comprehensive treatment of welding methods and their selection, including inert-gas shielded arc welding, resistance welding and pressure welding. Discusses performance of aluminum welds with an outline of methods for designing parts with welded joints. Tables give physical properties, alloy compositions and strengths of welds. (281)

Stainless Fasteners. American Screw Co., 7 pp. Gives physical properties and applications. Describes cold heading and other fabricating techniques. (282)

Welding. American Welding & Mfg. Co., 23 pp, illus. Describes company's welding facilities, including list of products and specific services available. (283)

Fused Quartz. Amersil Co., Inc., 2 pp, illus. Fused quartz for use in optical and electronic industries. (284)

Welding Electrodes. Ampco Metal, Inc., 4 pp, ill, No. W-25. Characteristics and properties of bronze welding electrodes, with list of specific applications for various grades. (285)

Welding Insert. Arcos Corp., 10 pp, ill. Welding process technique where welding is done on one side only by means of insert process. Suitable for butt welding of stainless and alloy steel pipe, both seamless and welded. (286)

Extensometer Comparator. Baldwin-Lima-Hamilton Corp., 2 pp, illus, No. 4210. Description of portable instrument for calibrating extensometers, compressometers, dial gages. Measurement and method of calibration outlined. (287)

Grating Spectrographs. Bausch & Lomb Optical Co., 8 pp, illus, No. D-272. Describes spectrograph with two gratings for greater dispersion flexibility. (288)

Black Light. Black Light Corp. of America, 65 pp, illus. Long wave ultraviolet light for display, industrial inspection, flaw detection, etc. Case histories plus data on research in this field. (289)

Heat Treating Ovens. Carl-Mayer Corp., 6 pp, illus, No. HT-53. Brief description of various types of heat treating furnaces and ovens. (290)

Manufacturers' Literature

Metallurgical Testing Equipment. Buehler Ltd., 12 pp, illus. Describes metallurgical specimen mount presses. (551)

Weldments. The Cleveland Welding Co. Illustrated brochure describes special process of radial welding of circular steel parts. (552)

Chromizing. Chromalloy Corp., 4 pp, illus. Applications of surface alloying technique for increasing heat, wear and corrosion resistance of ferrous metals. (553)

Roller Hearth Furnaces. Drever Co., 8 pp, ill, No. B-90. Profusely illustrates a variety of oil, gas or electrically heated, direct fired or radiant tube roller-hearth furnaces. Includes specifications. (554)

Explosive Rivets. E. I. du Pont de Nemours & Co., Inc., Explosives Dept., 32 pp, ill, No. A-2281. Complete data on two types of explosive rivets—high-speed industrial explosive rivets and aircraft explosive rivets. Specifications and installation procedures are included. (555)

Wrattan Filters for Technical Use. Eastman Kodak Co., 343 State St., Rochester 4, N. Y., 78 pp, price 75c. "Kodak Wrattan Filters for Scientific and Technical Use" lists over 100 filters having applications in black-and-white and color photography, and discusses forms and types of filters, their standard uses and care. Write direct to Eastman.

Atmosphere Generators. Gas Atmospheres Inc., 6 pp, ill, bulletins N-452 and 1-552. Brochures describing the features and applications of insert atmosphere generators and nitrogen atmosphere generators. (556)

Rotary Hearth Furnaces. Gas Machinery Co., 4 pp, ill, No. A-102. Complete specifications of the Gasmaco rotary hearth furnaces for forging, annealing, heat treating or drawing operation. (557)

Radiography. General Electric Co., X-Ray Dept. A new house organ, "Radiation Digest," devoted to industrial x-ray applications and commercial irradiation techniques. Contains news of the field and feature articles. Published quarterly. (558)

Furnace Temperature Indicator. Claud S. Gordon Co., 2 pp, ill. Describes device which quickly indicates any deviation from desired furnace temperature. (559)

Weldments. Graver Tank & Mfg. Co., Inc, 16 pp, illus. Describes company's welding facilities. (560)

Conveyor Furnaces. Harper Electric Furnace Corp., 4 pp, illus, No. 454. Describes mesh belt conveyor furnaces. Gives specifications and dimensions. (561)

Furnaces. C. I. Hayes Inc., 44 pp, illus, No. 112. Complete data on a variety of furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating, as well as on atmosphere generators and ammonia dissociators. (562)

Induction Heating Generators. Induction Heating Corp., 4 pp, illus. Technical data and case histories with applications of 2½- and 3½-kw induction heating generators. (563)

Heat Treating Furnaces. Industrial Heating Dept., Westinghouse Electric Corp., 38 pp, illus, No. B-5459. Complete description of Westinghoue furnaces—large and small, gas and electric. (564)

Tube Fittings. Imperial Brass Mfg. Co., 4 pp, illus. Tube fittings for use with stainless steel, nylon, polyethylene, aluminum, copper, and other tubing. (565)

Tablet Presses. Kux Machine Co., 4 pp, illus. Tabletting presses for production of powdered metal parts, ceramic parts, explosives, etc. (566)

Weldless Rolled Rings. Ladish Co., 4 pp, illus. Advantages and applications of high strength weldless rolled rings produced in weights up to 20 tons. (567)

Atmosphere Control for Heat Treating. Leeds & Northrup Co., 20 pp, illus, No. TD4-620(1). How to control surface carbon content automatically in heat-treating steel. (568)

Induction Heaters. Magnethermic Corp., 12 pp, illus. Describes low frequency brass and copper induction heaters for preheating metals. (569)

Welded Assemblies. The R. C. Mahon Co., 1 p, illus. Shows several examples illustrating the capabilities of welding for construction of various assemblies. (570)

Induction Heating Control. Minneapolis-Honeywell Regulator Co., 16 pp, illus, No. HT-1. Discusses automatic temperature control for induction heating equipment. (571)

Compression Tester. National Forge & Ordnance Co., 4 pp, illus. Describes crush compression tester for in-plant testing. (572)

Spectrograph. National Spectrographic Sales Corp., 8 pp, illus. Spectrographic equipment and accessories. (573)

Welding Studs. Nelson Stud Welding, Div. of Gregory Industries, Inc. Wall Chart No. 1. Dimensions and applications of standard MG studs. 12-pp booklet also available. (574)

High Frequency Heating. New Rochelle Tool Corp., 16 pp, illus. Describes the principles of induction and dielectric heating. Includes typical specific applications of high frequency heating in welding, brazing and heat treating. (575)

Wrinkle Finishes. New Wrinkle, Inc., illus. Folder shows typical products utilizing Wrinkle finishes. (576)

Hole Quencher. Palmer Mfg. Co., 4 pp, illus. Features advantages of using the I. D. Hole-Quencher for case hardening holes seven times faster. (577)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 69 and 70

Formed Wire Products. Peerless Wire Goods Co., Inc., 8 pp, illus. Facilities and services of company described in manufacture of wire products. (578)

Electric Furnaces. Pereny Equipment Co., 3 pp, illus, No. 4A. Booklet tells advantages and illustrates typical group of furnaces and kilns and their uses. (579)

Lettering Machine. Ralph C. Coxhead Corp., 4 pp, illus. Lists the many advantages of using the Vari-Typer lettering machine in the drafting room. (580)

Corrosion Resistant Coating. Specialty Coatings, Inc., Div. of Thompson & Co., 6 pp, illus. Examples of how Vinsynite Pretreatment was used in finishing six different types of metal products for good paint adhesion and corrosion resistance. (581)

Abrasive Materials. Sterling Grinding Wheel Co., 28 pp, No. 1-55. Catalog provides a quick means for selecting proper grinding wheels from factory stock and provides information for ordering custom-made abrasive tooling. (582)

Vacuum Furnaces. F. J. Stokes Machine Co., Inc., 8 pp, illus. Discusses effects of processing various metals and alloys in vacuum. Includes applications of vacuum furnaces in melting and casting new metals. (583)

Tubing. Superior Tube Co., 8 pp, No. 40. Information on selection and application of 46 principal analyses of tubing. Includes seamless and weld drawn tubing. (584)

Abrasion Resistance Tester. Taber Instrument Corp., 4 pp, illus, No. 5409. Tester evaluates resistance of surfaces to rubbing abrasion. Includes tests of painted, lacquered, electroplated surfaces and plastic coated materials. (585)

Blind Rivets. Townsend Co., 12 pp, illus. Types of Cherry Blind rivets and examples of their use in fabrication. (586)

Impact Tester. U. S. Testing Co., Inc. 2 pp, illus. Gives history, description and use of the SPI low temperature impact tester. (587)

Weldbrazing. Uniworld Research Corp. of America, 4 pp, illus. Special steel filler alloys combine fusion welding and brazing process. Applicable to all types of gas and electric welding with standard welding equipment. (588)

Weldments. The Van Dorn Iron Works Co., 10 pp, illus. Shows this company's facilities for producing weldments and other parts in all sizes and examples of the type of work produced. (589)

Electric Radiant Panels. Edwin L. Wiegand & Co., 6 pp, illus, No. CS605. Folder includes a variety of applications of Chromalox electric radiant panels—compact, "packaged" for infra-red generators. (590)

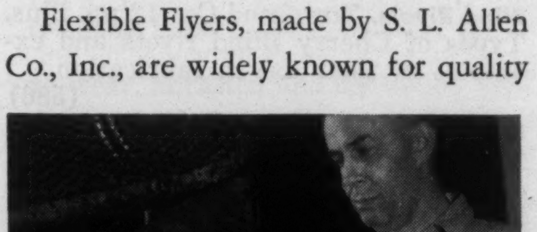
Remember your first sled?

What bigger moment in a youngster's life than when he selects his first sled! Especially if it's a Flexible Flyer, the same kind Dad had, years ago.

Flexible Flyers, made by S. L. Allen Co., Inc., are widely known for quality—quality that starts with those slim steel runners, formed from hot-rolled carbon-steel T-sections. The ones shown here, which were rolled at our Johnstown, Pa., plant, measure 11/16 in. deep by 7/16 in. across, with a 1/16 in.-thick stem. And a slight concavity, or groove, is rolled into the cross bar. Grooved runners grip icy surfaces, preventing skids and giving better control.

S. L. Allen save money by using Bethlehem special sections for their sled runners. They avoid costly machining, forming and fabricating operations—and they get a better product, besides.

A few other typical applications illustrating the widespread uses of Bethlehem special sections are truck tire rims, door hinges, lawn-mower blades, fence posts, window sash, and typewriter-carriage rails. Perhaps you could cut production costs by using special sections, hot-rolled to your drawings and specifications. For complete information we suggest that you contact the Bethlehem office most convenient to you.



A workman at S. L. Allen's Philadelphia plant rivets hardwood bars to the sturdy steel frame.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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One point of view

Needed: New Reinforcing Materials

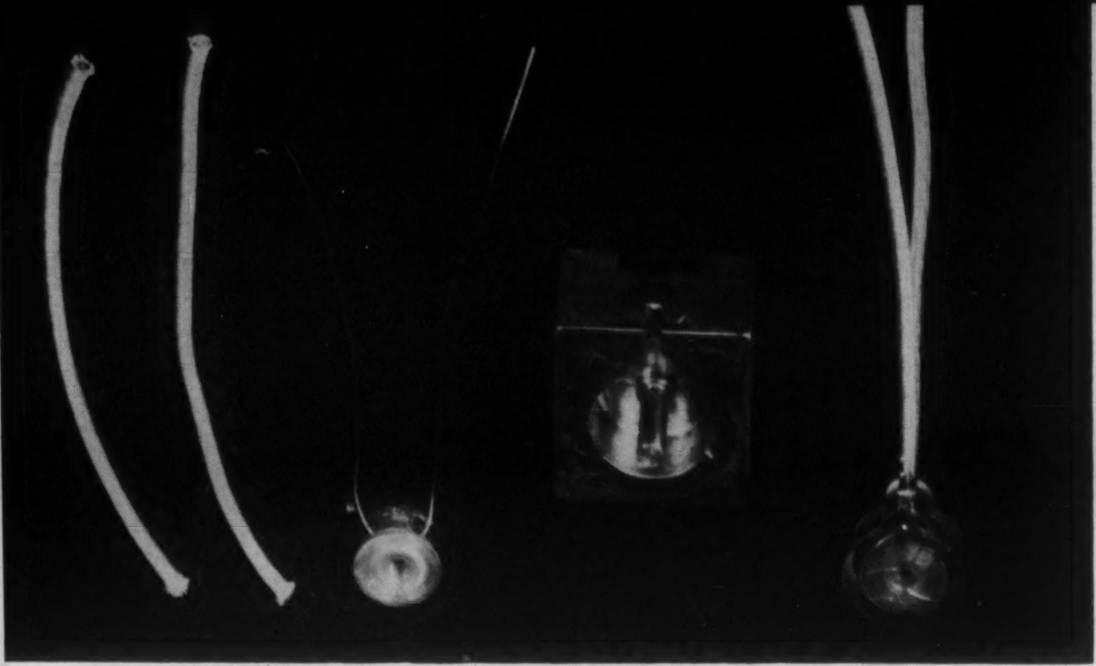
Interestingly enough, our minds are drawn to the matter of research and where it can be applied by two separate features in MATERIALS & METHODS this month. Coincidentally, both touch upon the desirability of finding a replacement for glass as a reinforcing material for plastics in structural applications. Perhaps that isn't stating the case exactly, for in at least one of the instances the thought is advanced that if as much research time and money were spent in the development of alternative reinforcing materials, some other natural or synthetic fiber might have the leadership that glass now enjoys.

One exponent of this point of view is Dr. Johan Bjorksten who is this month's Man of Materials (p. 9). Dr. Bjorksten has nothing against glass as a reinforcing median, but does recognize that there are certain limitations which now keep reinforced plastics from accepting tasks which must be accomplished. His point is that research plus aggressive selling put glass where it is. Similar effort could do the same for other materials. He suggests cotton which already has proved itself in some ways—but which has serious shortcomings. Also, new synthetic fibers might be useful as reinforcing materials in thermoplastic materials.

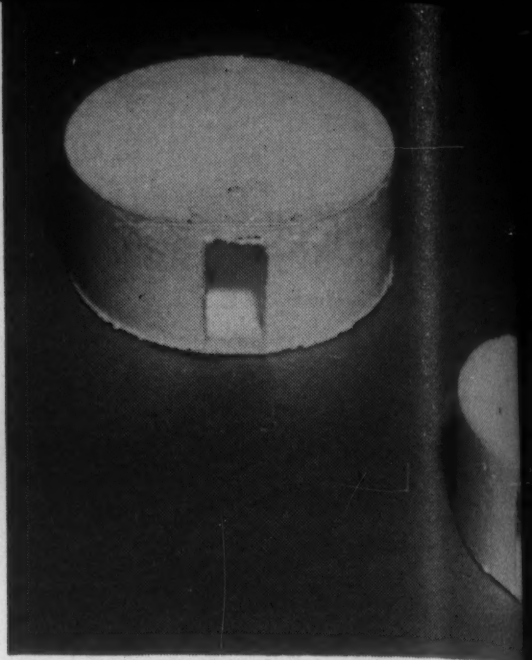
A final suggestion Dr. Bjorksten makes is that more use be made of asbestos fibers. Fibers of this type are now being used extensively in England in asbestos-phenolic combinations.

A report on the latter combination is given in an article starting on page 103. As can be seen, this material shows good promise, but at the same time it has several serious limitations. Development in this country has been slow because of a lack of asbestos fibers of the proper length. Now this lack has been overcome so it is possible for this country's technicians to find out how asbestos fits into the requirement picture of the future.

Previously we stated that Dr. Bjorksten had nothing against glass fibers. Nor do we. We merely take this opportunity to suggest that these fibers have definite limitations—as do all engineering materials—and that no alternative will be found until properly directed research has proved fruitful and then sold aggressively.



Materials for impregnation *and encapsulation of a pick-off coil. Machined metal mold is in center with the coil and woven glass tubing at right. At left is the completed assembly embedded in clear polyester resin.*



Foamed polystyrene *(density of materi shown is 5 lb/cu ft) can be used for hi frequency applications.*

Casting Resins Insulate and Protect Electronic Components

Which resin to use depends upon the conditions of your specific application.

by H. L. Loucks, *Materials and Process Engineer, Bell Aircraft Corp.*

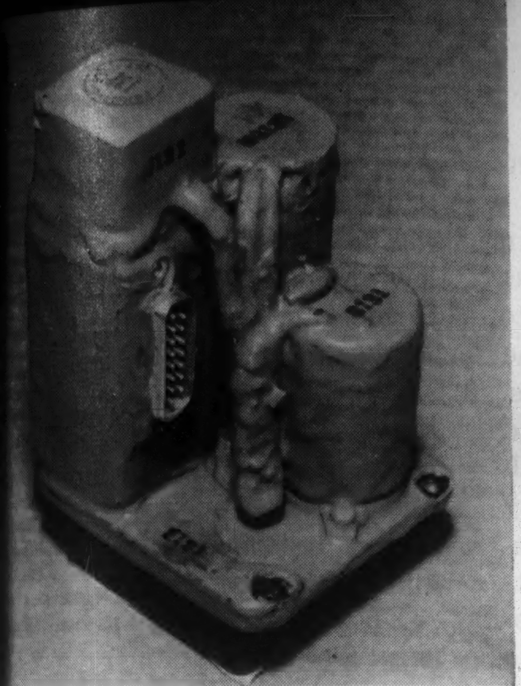
■ Plastics casting resins are used for embedment, encapsulation and impregnation of electronic circuit subunits and components as well as for surface coatings. The resins may become integral with the component providing a high degree of electrical insulation, and/or serve to protect the unit externally from moisture, dirt, abrasion, chemicals and thermal and physical shock, depending on whether the fundamental design need is dielectric or mechanical.

At present, no single casting resin is capable of meeting all requirements of the many different casting, encapsulating and impregnating applications. For each application, resin systems must be evaluated in light of the conditions associated with the environment of that particular embedded component, and a resin system must be selected to meet those conditions. This article deals with polyester and epoxy resins, foam-type resins such as polyisocyanates and polystyrenes and elastomeric resins such as polysulfides and silicone rubber compounds.

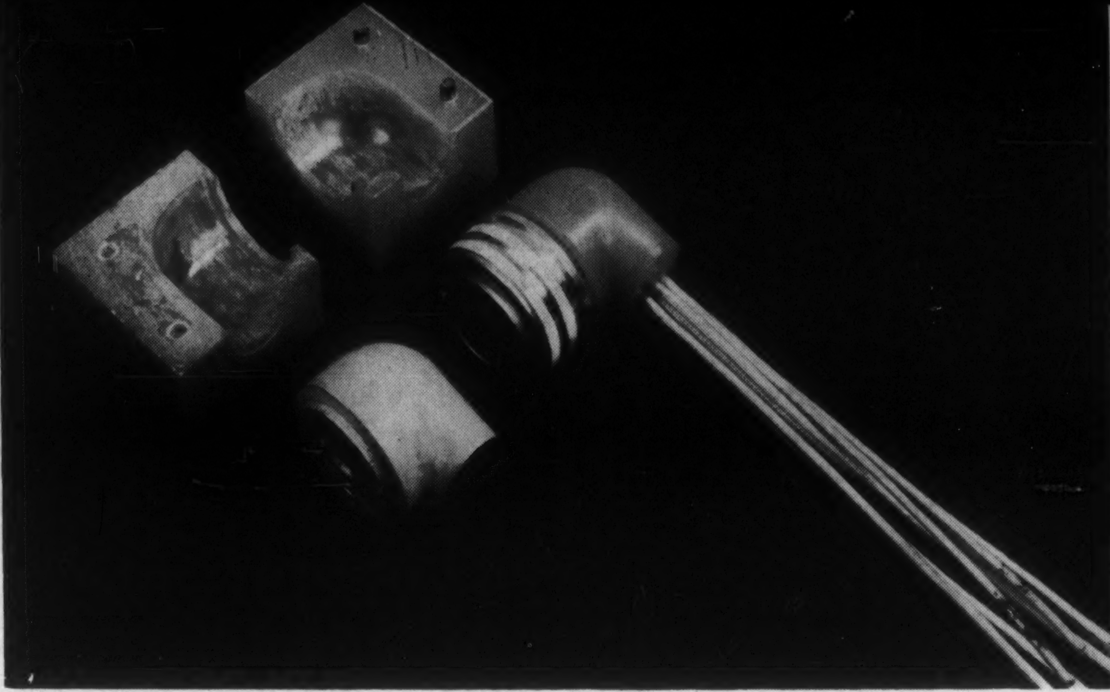
Pros and cons

Advantages of embedment include the following:

1. Resistance to moisture, chemicals, fungus, dirt and other environmental conditions and/or changes.
2. Maintenance of desired electrical properties over a specified temperature range.



***Silicone rubber** is used to encapsulate these electrical components for the autopilot system of a Bell helicopter.*



***Talc is used** to fill this polyester casting for an amphenol right angle connector socket. The two-piece polyester mold at left was fabricated from the wooden pattern.*

3. Resistance to vibration and shock for delicate components.
4. Elimination of metal cans, brackets, terminals and mounting strips.
5. Permits grouping of parts into modular components, allowing miniaturization since three-dimensional packing is feasible.
6. Reduction of maintenance and increased reliability.

On the other hand, there are definite limitations to embedment though these usually can be eliminated or made tolerable through the cooperation of the resin chemist and design engineer.

Some of the major limitations and steps taken to minimize or eliminate their restrictive effects are as follows:

Potting vs Embedment

The old method of potting electronic units by placing them in metal cans and pouring in hot melts such as tars, pitch or asphaltic materials is becoming outmoded. The present-day term "potting", as used in the aircraft industry, usually means embedment, encapsulation or impregnation of electronic components in high polymer resins.

Resins have many advantages such as low shrinkage, room temperature cure, good resistance to environmental conditions and high electrical properties.

1. Internal stresses and heat dissipation. Embedment of heat sources such as subminiature tubes, which have high volatage dissipation, thus increased heat output, presents a problem because casting resins are usually poor thermal conductors. Internal stresses are caused by a) exothermic reaction heat of the resin, b) differentials between thermal coefficients of expansion of resin and embedded components, and c) shrinkage of the resin during cure. Resulting stresses can cause cracking of the resin during high and low temperature cycling or can break delicate components.

Proper design will minimize these disadvantages. Components must be properly spaced to prevent heat build-up and to keep hot components away from temperature sensitive elements. Stress centers such as sharp corners on components should be modified or covered with a resilient material such as silicone rubber. Heat can be dissipated from hot tubes by metal conductors leading to the resin surface. Coating delicate components with silicone rubber prevents damage to the components due to resin shrinkage. Choice of proper cure and resin-catalyst-filler system will minimize or eliminate internal stresses and high exothermic heat. Fillers can increase thermal conductivity of the resin, decrease shrinkage and equalize coefficients of expansion of resin and components.

2. Weight increase and difficulty of repair. For an expendable application such as guided missiles, the advantages of embedment generally outweigh these disadvantages. The reliability of an embedded assembly is only as good as the reliability of each of its components. Failure of any single component usually means replacement of the entire embedded assembly. Embedded assemblies should be considered as expendable items which can be replaced quickly without need for skilled maintenance personnel.

Where components must be repaired, several methods can be used. The potted unit can be immersed in hot methylene chloride, though the solvent also attacks vinyl wire-covering and can destroy components. Castings can also be drilled, or softened with soldering irons. Problems of increased weight can be solved by use of light-weight foam resins, providing service temperature limits do not exceed temperature limits of the resin used.

3. Non-resistance to oxidizing agents. Casting resins are not resistant to oxidizing agents such as those used in guided missiles. Some resins, such as epoxies, can be protected for periods of less than one hour by protective coatings. There are also thermosetting resins available that will

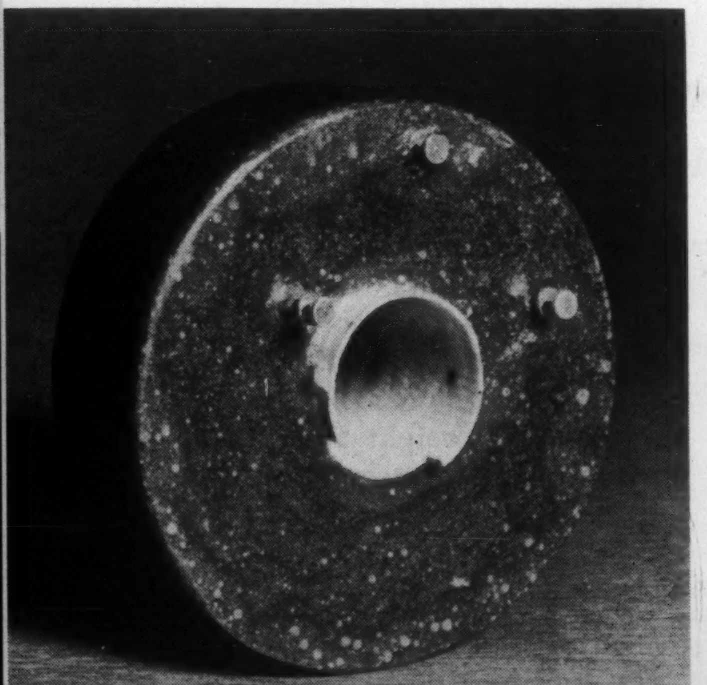
withstand oxidizing acid fumes for short periods of time without protective coatings. Thermoplastic resins of the ethylene family are the most resistant to oxidizing acids, but lack the production workability of thermosetting casting resins.

Other limitations of casting resins, such as dielectric properties and temperature limitations must be worked out between design engineer and resin chemist. Average electrical properties can be obtained from most casting resins at low frequencies. More expensive resins are available for high frequency work.

Polyesters and epoxies

Polyester and epoxy resins are both 100% reactive resins. No by-products are given off in the polymerization reaction. Due to their relatively high dissipation factor and high dielectric constant they are considered as low frequency resins.

Both resins are used, filled and unfilled, for embedment, encapsulation and impregnation. Epoxy resins are generally used when high adhesion and low moisture absorption are of great importance. Both can be mixed, poured and cured on the job at room temperature.



***Laminated polyester-glass** cloth tape is used in the center section of this high voltage transformer coil. Terminals are embedded in mica-filled polyester.*

Polyester systems are lowest in cost, easy to handle and not as toxic as epoxy systems. Their 7 to 9% shrinkage by volume can be lowered by use of proper fillers. They exhibit average physical and electrical properties, and both rigid and flexible compounds may be prepared by resin blending. Selection of proper resin-catalyst-promoter-filler systems can provide materials that will operate satisfactorily over a service temperature range of —65 to 300 F.

Polyesters are cured at room or elevated temperatures with aldehyde or ketone peroxides such as methyl ethyl ketone peroxide or cyclohexanone peroxide; with diacyl peroxides such as benzoyl peroxide paste; or with alkyl hydroperoxides such as t-butyl hydroperoxide. These peroxides are liquids or pastes consisting of the base catalyst and an organic phthalate. Common promoters are heavy metal salts such as cobalt, naphthanate, or dialkyl aryl tertiary amines such as diethyl aniline.

Polyesters are often polymerized at room temperature with alkyl hydroperoxides or cyclohexanone peroxide, without promoters, if a long cure time can be tolerated. Or they can be cured at high temperatures with diacyl peroxides such as benzoyl or lauroyl peroxide. Granular catalysts are dispersed in a small amount of styrene monomer before they are added to the base resin.

Epoxy resins are noted for their low shrinkage, excellent adhesion to metallic and nonmetallic components and good mechanical strength. They have a lower moisture absorption rate than polyesters. Risk of dermatitis in handling epoxy systems can be controlled by proper mixing and handling techniques.

Epoxies are cured at room temperature with amine-type hardeners, then post-cured at oven temperatures to obtain maximum electrical and physical properties. Acid hardeners such as phthalic anhydride are used with the heat-setting, solid epoxies which are usually cured at temperatures of 200 F or above. Amine hardeners, unlike acid hardeners, cause a high exothermic reaction, causing polymerization of the resin at ambient temperatures.

Polysulfides and silicone rubbers

Elastomeric type materials used at Bell Aircraft are the polysulfides and silicone rubber. Polysulfide liquid polymers are noted for their resistance to aircraft fuels and hydraulic oils, low permeability to liquids and gases, good resistance to salt spray and oxidation, good flexibility at −65 F and good electrical insulating properties. Cured polysulfides have fair tear strength and a fairly low compression set. Operational temperature limits vary

***Typical electronic component** grouping embedded in filled polyester resin. Simple metal mold is shown at right.*

from 180 to 300 F depending on formulation used. They can be used as dielectric sealers for electrical connectors and as protective coatings.

Polysulfides are obtained as a two-component system consisting of a solvent-free compounded polymer with an accelerator. The accelerator is usually based on a dispersion of lead dioxide in a solvent such as toluene. Cure takes place at low temperature with very little shrinkage. Heat and humidity accelerate the curing process. Working life of the catalyzed material can be increased by lowering ambient temperature and humidity.

Polysulfide polymers may also be copolymerized with epoxy resins to form products varying from flexible to hard. Polysulfides provide epoxies with lower temperature flexibility, lower exotherm, lower water vapor transmission, lower cure shrinkage and increased flexibility. Main disadvantage in such compounds is lower heat resistance.

Outstanding properties of silicone rubbers include excellent dielectric properties, oxidation resistance, flexibility over a temperature range of —60 to 500 F, resistance to salt spray, moisture, vibration, and shock, and good thermal conductivity. Their major disadvantages are poor tensile and tear strengths, and low resistance to acids, alkalies and some solvents and oils such as silicone oil or hydraulic oil.

Silicone rubbers are obtained as two-component systems which are diluted with toluene before mixing. The diluted mixture is then applied by dipping or brushing and cured at room or slightly elevated temperature. Desired thickness is built up by successive brush or dip coats followed by cure. Though mainly used as a protective coating material, silicone rubber compounds are currently being evaluated for use as potting and embedment materials.

Foams

Both polyisocyanate and polystyrene foams have been used successfully to provide a lightweight embedment which can be foamed in place. Expansible polyisocyanate resins provide rigid or flexible foams ranging in density from 3 to 35 lb per cu ft. The resins are obtained as two-component systems. Modification of the chemical constituents provides either rigid or flexible foams with open or closed cells and with varied weight, strength and thermal insulating and electrical properties.

Polyisocyanate resins have low density, high strength-to-weight ratios, low moisture absorption, low thermal conductivity, good adhesion to other materials, and resistance to oils, greases, hydraulic fluids and solvents. They have low dielectric constants and power factors. Formulations are available that resist temperatures above 300 F. Rate of foaming can be controlled by cooling the two components of the resin system. Adhesion to adjacent materials can be improved by priming surfaces with a synthetic rubber solution. In uses where the low thermal conductivity of foams is outweighed by other factors, heat conductors, such as metal foil, can be used to carry heat from components to the foam surface.

Resins used

There are a variety of resins, resin modifications and cures used to obtain different combinations of physical and mechanical properties to meet specific applications. It would not be feasible, and could be misleading to present here comparative mechanical and electrical properties of the various materials used. However, resins used by Bell Aircraft are as follows:

Polyesters:
Selectron 5003 and 5026 (Pittsburgh Plate Glass Co.)
Paraplex P-13 (Rohm and Haas Co.)

Epoxies:
Scotchcast 2 and 3 (Minnesota Mining & Mfg. Co.)
Epon 828 (Shell Chemical Co.)
Araldite E-211 (Ciba Co., Inc.)

Polysulfides:
PR 1201-Q (Products Research Co.)
EC 1120-PC (Minnesota Mining & Mfg. Co.)

Silicone rubber:
RTV 5302/5303 (Dow Corning Corp.)

Isocyanate foam:
Lockfoam Series A (Nopco Chemical Co.)

Polystyrene foam:
Dylite (Koppers Co., Inc.)

Diisocyanates are toxic; however, this hazard can be reduced by normal precautions such as proper ventilation and prevention of excessive skin contact.

Polystyrene resins exist as thermoplastic granules that can be transformed by heat into strong, light-weight foams with a closed cell structure. Unlike isocyanate foams, they consist of one-component systems with an incorporated blowing agent. Densities of less than 2 to more than 10 lb per cu ft can be obtained by varying the quantity of granules placed in the mold. Temperatures of 230 to 275 F are used to expand the material.

Polystyrene foams offer low density, high strength-to-weight ratios, low moisture absorption, low thermal conductivity and a lower dielectric constant and power factor than isocyanate foams. They are unaffected by aliphatic hydrocarbons and alcohols, but are soluble in aromatic and chlorinated hydrocarbons, ketones and esters. They do not possess the excellent adhesion of isocyanate foams and therefore require adhesives for bonding to metallic or nonmetallic components. One advantage of the polystyrenes is that the foam is not affected by radio frequency waves, whereas isocyanate foams tend to burn at similar high power levels. On the other hand, polystyrene foam resins are not as easy to work with as the isocyanates.

Fillers

Fillers are added to epoxy and polyester resins to alter their characteristics for specific applications. They may be used to reduce shrinkage, reduce cracking during thermal cycling, increase thermal conductivity, raise heat distortion points, increase impact strength and control exothermic heat generation. By selection of the proper type and amount of filler, the coefficient of thermal expansion of the resin can be matched with that of the metallic or nonmetallic components being embedded. It should be mentioned that fillers may improve mechanical properties of a resin at the expense of dielectric properties. A compromise is usually necessary to obtain the best combination of electrical and mechanical properties.

Typical filler materials include mica, silica, talc, calcium carbonate, asbestos, quartz, glass beads, aluminum oxide, sand and powdered metals such as aluminum or steel. Frequently a thixotropic filler such as diatomaceous silica, colloidal silica or aerogel is added to prevent settling of the filler. A good filler should 1) be compatible with the resin system, 2) be easily wetted by the resin, 3) have low water absorption and moisture content, 4) improve electrical and/or physical properties without a detrimental increase in viscosity; and 5) provide a smooth, nonporous surface finish on the cured resin.

Mica has excellent electrical properties and low water absorption. Both mica and talc lower linear shrinkage of polyesters substantially. Calcium carbonate causes premature gelation of polyesters, and is therefore usually used with epoxies. Asbestos mixed with epoxy resins produces a plastics putty for mounting hardware. After 8 days, compressive strength of the material builds up to approximately 12,000 psi. Metallic fillers, such as aluminum or steel, can greatly improve thermal conductivity, though they cause a noticeable decrease in dielectric properties.

Cures

A common phenomena of most thermosetting casting resins is evolution of heat during cure. Exotherm temperatures as high as 300 or 400 F have been recorded for polyester, epoxy and polyisocyanate resins. This heat evolution must be carefully controlled. A high peak exotherm may cause excessive resin shrinkage, damage to embedded components or cracking of the casting. On the other hand, a low exotherm may result in an incomplete cure.

Since many embedding and encapsulating applications, such as potting connectors or surface protection of in-place components, must be done "on-the-spot" room temperature curing resin systems have been developed. Though such resins do not obtain maximum electrical and physical properties at once, they do become hard enough to be handled within a short time and thus offer a definite advantage to the production man. Heat lamps can be used for "on-the-spot" cures where heat is necessary.

Silicone rubber compounds, polyisocyanate foams and polysulfide resins are used as-supplied by the resin formulator. Usually they are cured at room temperature or at slightly elevated temperatures.

Air frequently inhibits the cure of polyester resins, leaving the exposed surface in a tacky state. Inhibition is prevented by placing dry glycerine, silicone oil, cellophane or polyvinyl alcohol sheet over the resin surface in the gel stage. Large crack-free castings have been made from filled polyester resins by decreasing or leaving out the promoter. The resin may require at least 24 hr to reach a hardened state due to the mild exothermic temperature.

Embedding Technique

1. A mold is prepared with the proper dimensions for the plastics cast. Molds may be of materials such as wood, metals, plaster of paris, flexible plastics or rigid plastics. Choice of mold material depends on type of resin being used, configuration of finished embedment, and production quantities. Dimensions must be such that the cast plastics shall be no less than 0.060 in. thick over any portion of the embedded part or assembly, and insulation on lead wires must extend at least 0.20 in. into the cast.

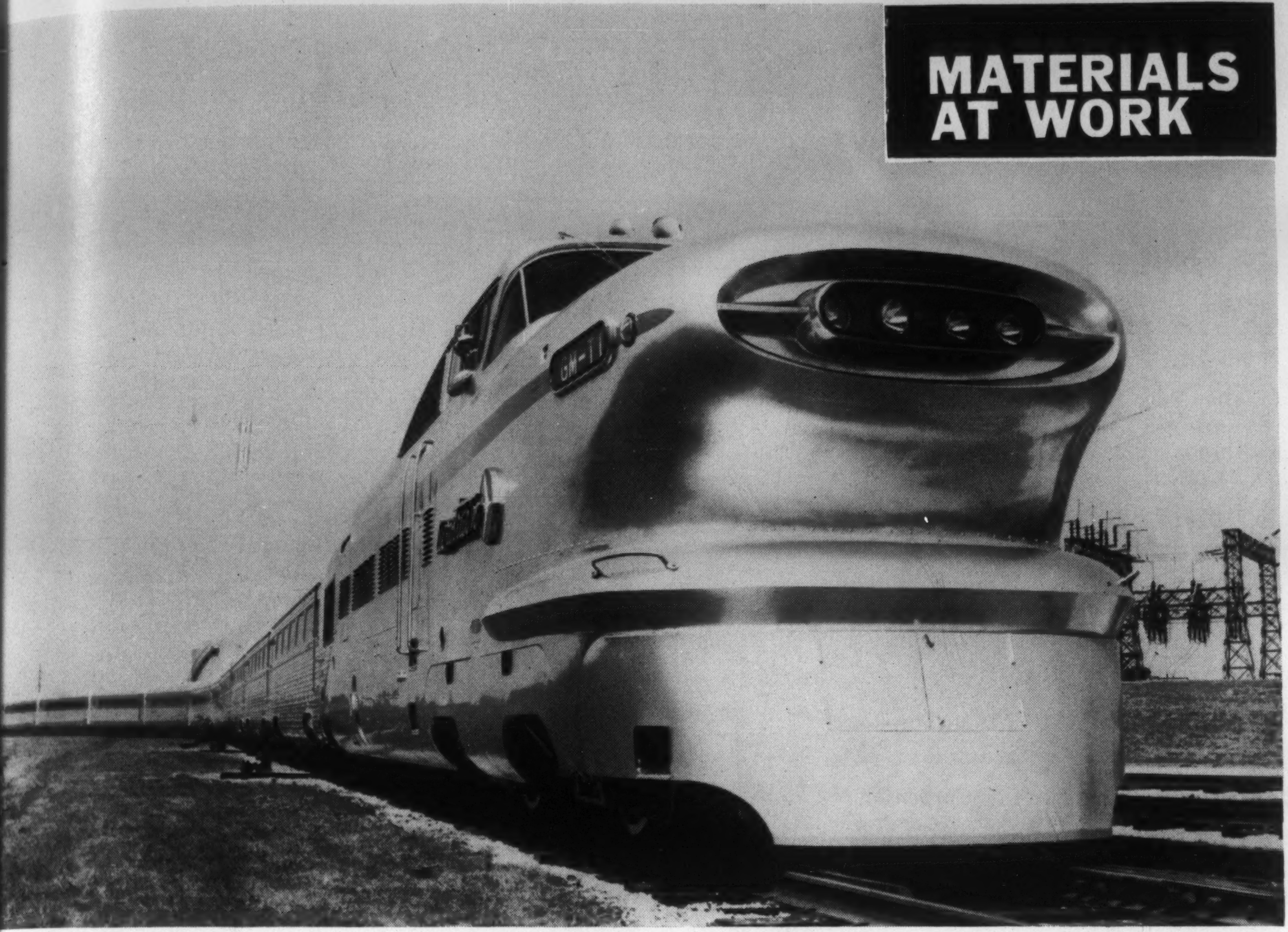
2. The mold is thoroughly cleaned with solvent, and a release agent applied to all mold surfaces which will come in contact with the plastics. The most common release agents used are silicone oils and greases, cellulose acetate lacquer and vinyl solutions. Polyvinyl alcohol, polyethylene and fluorocarbon resins also provide good release surfaces. Detergent solutions and surfactant solutions are used as release agents for flexible silicone rubber compounds. Choice of release agent depends on resins being used.

3. The mold is positioned around the part and leakage spots are sealed with a latex emulsion or melted beeswax.

4. The resin and catalyst are weighed out and mixed until homogeneous. Colors or fillers are added at this time, and the resin system is poured into the mold on one side in a narrow stream in order to flush out any air as the resin fills the mold.

5. The resin is allowed to cure at room temperature, followed by a post-cure at a higher temperature if maximum electrical and physical properties are desired.

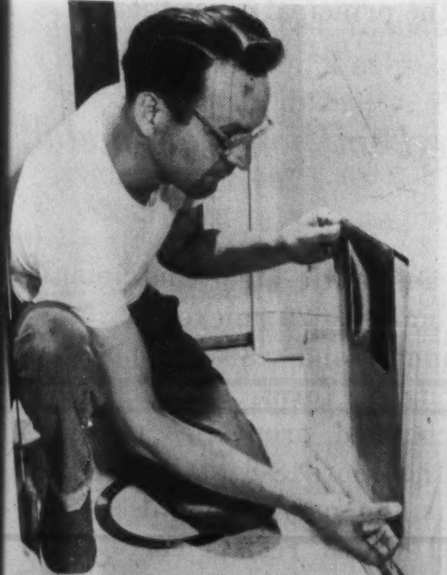
MATERIALS AT WORK

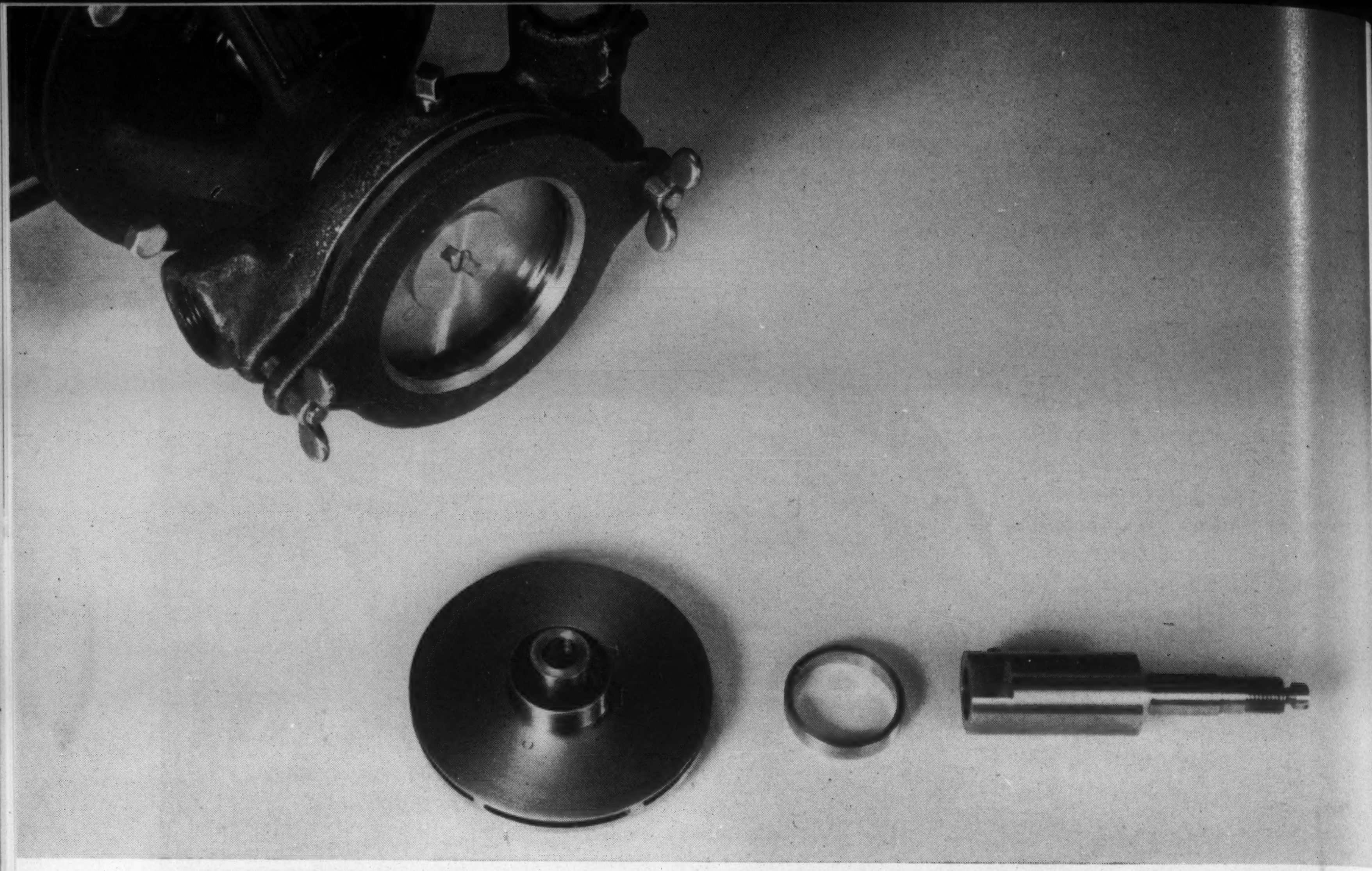


Stainless steels guard lightweight train

Stainless steels are used liberally throughout General Motors' new lightweight Aerotrain recently put into service. Two of the new 40-passenger coaches weigh 30 tons, compared with 65 tons for one conventional 80-passenger coach. The new coaches are 40 ft long, 10 ft 9 in. above the rail and 9 ft 6 in. wide. The lower sections of the coaches are covered with stainless steel.

Other uses for stainless steels include kick plates for entrances, baggage compartments under the seats, and cup disposal units. Stainless steels were supplied by Allegheny Ludlum Steel Corp.





Centrifugal pump *made of Carpenter No. 20 for resistance to corrosive acid solutions.*

Rare Earth Stainless Steels

by H. O. Beaver, *Plant Metallurgist (Melting),* **and B. T. Lanphier,** *Metallurgist (Stainless Steels), Carpenter Steel Co.*

■ The immediate advantage of the addition of misch-metal was first realized in steel mill operations when it became apparent that improved yields of a usable product were obtained from many of the standard stainless steel analyses. It was found also that some alloy conservation was possible.

For instance, many of the highly alloyed stainless steels require a nickel content above that needed for ideal mechanical properties in order to obtain the proper commercial degree of hot workability. The use of misch-metal in alloys of this nature enables the producer to conserve nickel without loss in hot working properties.

The alloying addition of rare earth metals is made to the molten bath of steel by adding cast forms of misch-metal, an alloy of these metals with the elements cerium and lanthanum as the principal constituents.

Users benefit in 3 ways when stainless steels are alloyed with misch-metal:

1. *New wrought alloys with unusual properties are produced.*

Sulfuric acid resisting grade

Hot working improvements obtained with misch-metal additions have led to the development of alloys which could not, under ordinary circumstances, be manufactured commercially. The most significant development in this field is a sulfuric-acid resisting wrought stainless steel. This alloy, Carpenter Stainless No. 20, had been available previously in cast form only as Durimet 20. It is now produced in wrought bars, strip, wire, tubing, sheet, and plate. Availability of the wrought product has materially extended the applications of this composition.

Carpenter Stainless No. 20 is an austenitic steel containing 20 chromium, 29 nickel, 2 molybdenum, and 3% copper. In wrought form the alloy has mechanical properties equivalent to those of 18-8 stainless steels. It is the only wrought stainless steel which resists corrosion by hot sulfuric acid. It can be safely used in boiling concentrations up to 10% and resists all concentrations at 175 F (80 C). Prior to the introduction of stainless No. 20, Type 316 was considered the most corrosion resistant wrought stainless steel. Relative corrosion resistance of these two steels to sulfuric acid is shown in a table.

A specific comparison can be made in an application in which Carpenter 20 and Type 316 rods were installed simultaneously to handle hot sulfuric acid (160 F) at the rate of 50 gal per min in concentrations ranging from 0 to 58%. Type 316 rods failed in 4 days. After 3740 hr service, Carpenter 20 rods showed no evidence of attack.

New valve steel

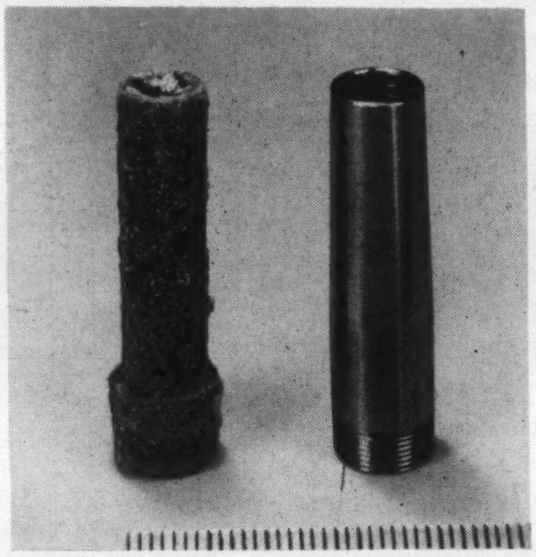
Another example of a new alloy development attributed directly to the use of misch-metal is 21-12N high temperature valve steel. The exhaust valve of an internal combustion engine requires a material with high strength and corrosion resistance at elevated temperatures. The best available steel contained 21 chromium and 12% nickel. However, even this alloy did not have sufficient hot strength for some high compression engines. Addition of nitrogen to this base analysis materially improved the high temperature strength of the alloy but at a serious sacrifice in hot forgeability. The addition of misch-metal to the 21-12 analysis, containing nitrogen, converted the alloy to one that could be produced commercially in the steel mill and subsequently forged without difficulty. Properties are compared with those of original steel on p. 98.

Manufacture of an exhaust valve involves a rather severe forging operation; one that requires optimum hot workability to prevent ruptures or tears on the rim or seat areas of the valve. The superior forging properties of misch-metal alloyed steel are clearly illustrated in a figure. The steel is used as head material in 2-piece exhaust valves for diesel and gasoline engines.

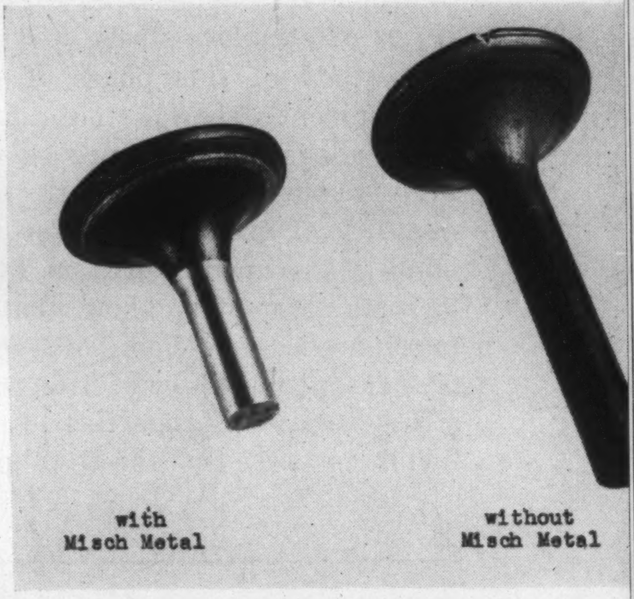
RESISTANCE TO SULFURIC ACID CORROSION

% Sulfuric Acid	Test Temp, F	Corrosion Rate—In. penetration per mo	
		Carpenter Stainless No. 20	AISI Type 316
10	70	No attack	0.0000
40	70	No attack	0.0102
65	70	No attack	0.0120
78	70	No attack	0.0042
10	176	0.0004	0.0040
40	176	0.0020	0.4727
65	176	0.0027	0.4560
78	176	0.0034	0.0263
93	176	0.0022	0.0126
10	Boiling	0.0031	0.0375

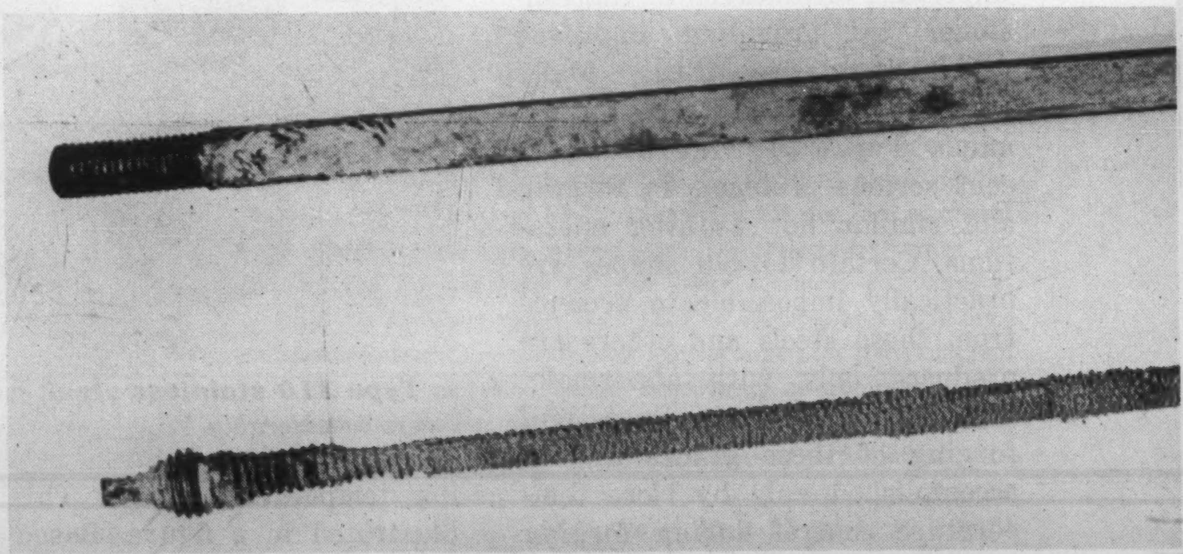
Note: Data for 240-hr immersion test consisting of five 48-hr periods.



Battery filling nozzles *for handling 12% sulfuric acid at 78 to 130 F. 18-8 nozzles (left) were badly corroded in 2 wks while Carpenter No. 20 nozzles showed no attack after 9 mo.*



Exhaust valve forging *of 21-12N high temperature valve steel. Valve not containing misch-metal shows tears on periphery.*



Half-in. dia rods *of Carpenter No. 20 and stainless Type 316 were installed simultaneously to handle hot solutions (158 F) ranging from 0 to 58% sulfuric acid flowing at 50 gal per min. Type 316 rods (below) failed in 4 days. No. 20 rods (top) showed no apparent corrosion after being in service for 3747 hr out of a possible 6144 hr over a period of 256 days.*

2. *Mechanical properties in austenitic stainless steels, such as Type 310, are improved.*

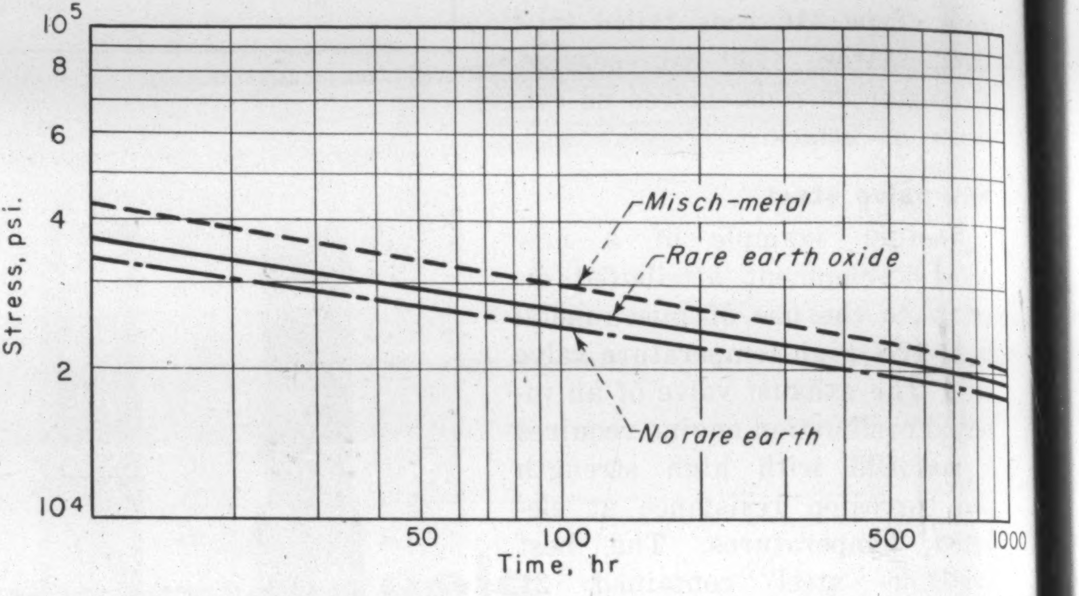
In addition to improved hot-working properties, rare earth additions improve mechanical properties in the finished product. It has long been recognized that rare earth additions to low alloy steels improve toughness and ductility but little attention has been paid to the effect of such additions on the mechanical properties of stainless steels.

A study of this phase of the development shows that rare earth alloys clearly improved the high temperature strength and ductility of these steels. For example, experimental data on Type 310 stainless steel show that a misch-metal addition of four pounds per ton will improve stress rupture properties by a factor of 25% at the 100-hour life level.

COMPARATIVE MECHANICAL PROPERTIES OF 21-12 AND 21-12N EXHAUST VALVE STEELS

	Test Temperature, 1400 F	
	21–12	21–12N
Tensile strength, psi	45,000	50,500
Yield strength, 0.2% offset, psi	—	28,500
Elongation, 2 in., %	35	24.5
Reduction of area, %	46	28.0
Brinell hardness No.	80	113
Stress to produce rupture, psi (1350 F, 500 hr)	11,500	13,000
Elongation, 1 in., %	32.0	41.0
Reduction of area, %	30.0	40.0

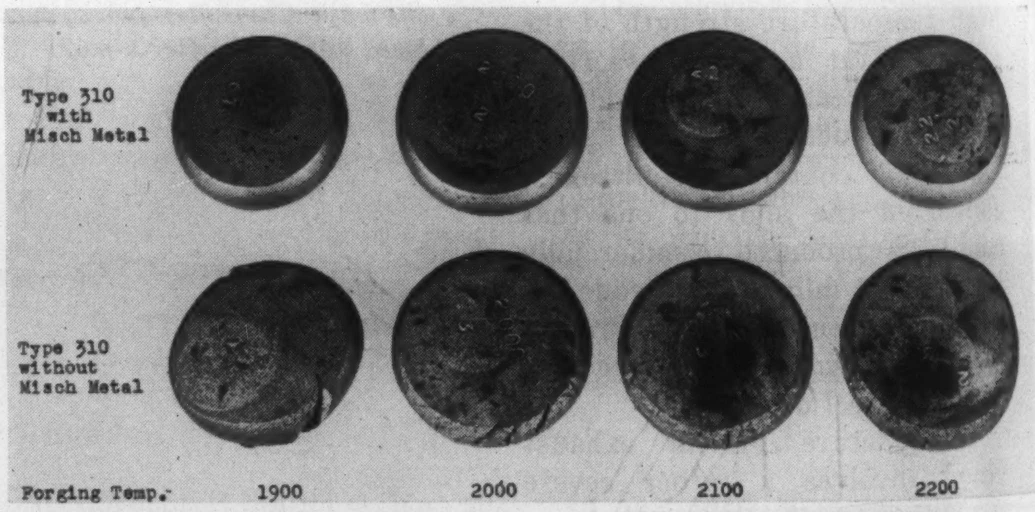
Note: Stress-rupture specimens annealed at 1900 F, water quenched.



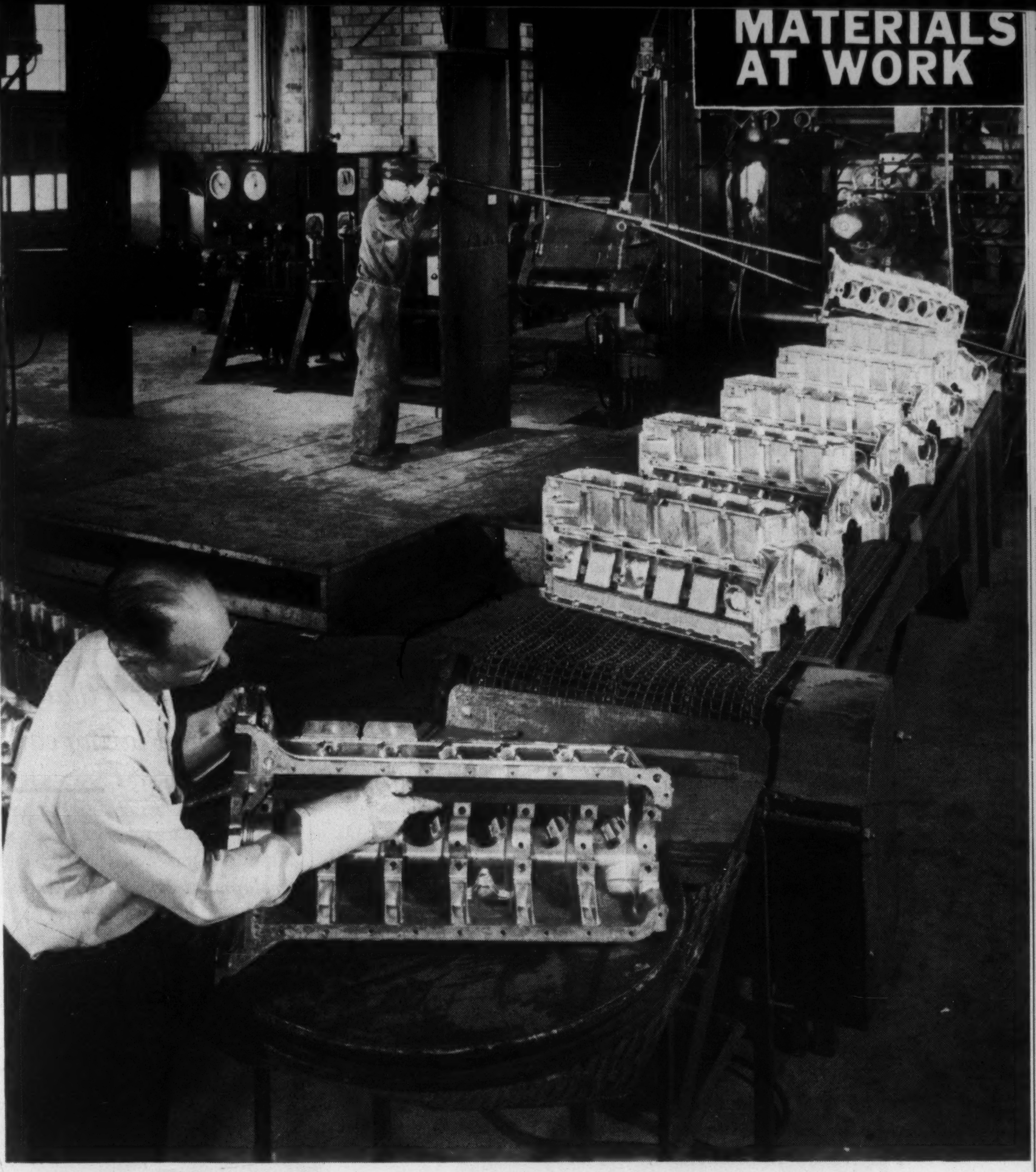
Stress rupture tests at 1200 F show the strengthening effect of rare earth additions to Type 310 stainless steel.

3. *Hot working properties are improved which means lower fabricating costs.*

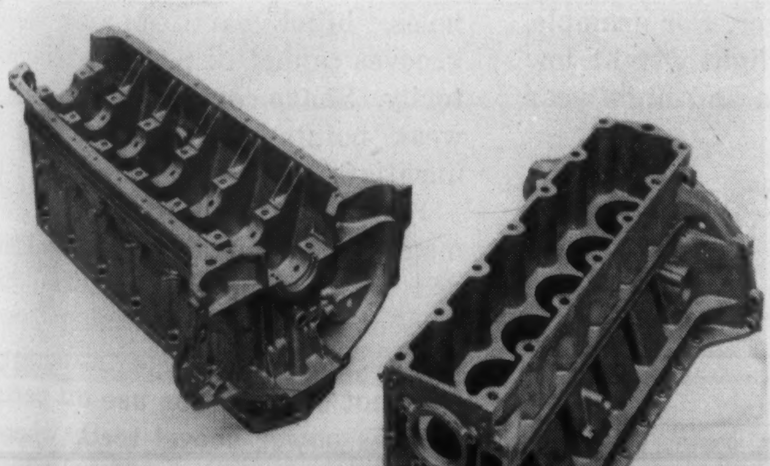
In addition to opening up new fields of alloy development, misch-metal alloyed steels offer important advantages to the consumer by providing improved fabricating properties. Many standard stainless steels, for example Types 310 and 316, present serious problems in forging and similar hot working operations. Certain forged shapes are practically impossible to produce from these steels and others are produced only with abnormally high rejection rates. Successful forging of these grades can be accomplished only by close temperature control during forging accompanied by frequent reheating. The misch-metal alloy addition generally improves the forgeability of these steels, but more important, it broadens the forging temperature range. This is illustrated in a figure. Based on these results, Type 310 stainless steel not containing misch-metal would be considered a forgeable alloy in the temperature range 1900 to 2000 F. However, this steel is subject to overheating accompanied by edge-cracking as shown by the specimens forged at 2100 to 2200 F. The misch-metal alloyed Type 310 shows excellent forging properties over the entire range.



In Type 310 stainless steel, *misch-metal broadens the forging temperature range considerably.*



Aluminum engine blocks are die cast



Said to be the largest die castings ever made in aluminum, these six-cylinder engine blocks, weighing 50 lb as-cast, are being produced on an experimental basis by Doehler-Jarvis. The same engine block in gray iron would weigh 175 lb. Machined weight of the aluminum block is 43 lb. All holes are cored and cast, and machining is confined to the main sealing areas. The project was carried out jointly by National Lead Co. and Kaiser Aluminum and Chemical Corp. An aluminum engine block could be produced at a 10% price advantage over conventional gray iron, according to National Lead.

Due to the efficient thermal conductivity of aluminum, a less complicated cooling system would be needed, and smooth surfaces of aluminum die castings prevent occurrence of uncontrollable sections and sand pockets, restricting flow of cooling water. The new blocks can be produced at a rate of 30 to 35 per hr on a single machine. A die cast V-8 aluminum block is now under development.

Try Flame-Plated Coatings

▸ *This hard surfacing method was introduced several years ago (see M&M October 1952).*

▸ *Applications include aircraft engine parts and accessories, high pressure hydraulic system parts, knives for cutting various nonmetallic materials, textile machine parts, forming tools and dies, canning machine parts and plug and ring gages.*

▸ *Developments have shown that parts coated with tungsten carbide by Flame-Plating can give satisfactory service under these conditions:*

by M. A. Teter, *Development Engineer, Linde Air Products Co.*

■ Tungsten carbide is deposited by Flame-Plating as a coating ranging in thickness from 0.002 to 0.010 in. The hardness of the coating averages about 1350 Vickers. Although the carbide particles are harder than this, the cobalt matrix reduces over-all coating hardness.

After Flame-Plating, the surface of the workpiece looks and feels like fine emery paper. Smoothness of the coating is about 125 microinches rms, measured by the Brush Analyzer. The part can be used in this condition or finished to various degrees of smoothness by standard carbide finishing methods. By diamond grinding and lapping, the coating can be finished to less than 1 microinch rms.

Many parts such as mandrels, industrial knives, and rocker arms can be used in the as-coated condition, that is with an average smoothness of 120 to 130 microinches rms. Others such as gages, seals, core rods and forming dies require smooth wearing surfaces. For these applications, the coating is ground and sometimes lapped to a finish as fine as 0.5 microinches rms.

Thermal shock resistance of the coatings is excellent. Tests have shown that they will withstand repeated rapid cycles of heating and cooling between 1350 and 120 F without failure. Resistance to thermal shock and mechanical shock is a function of coating thickness however, and coatings not more than 0.003 in. in thickness have maximum resistance.

Base metal can be steel, cast iron, aluminum, copper, brass, bronze, molybdenum, nickel, magnesium, titanium and their alloys. The ability to use a variety of base metals opens a wide field to the design engineer. For example, a combination of light weight, low moment of inertia and high wear resistance can be obtained by coating aluminum, magnesium or titanium. Because base metal temperature seldom exceeds 400 F, changes in the mechanical properties of the metal and distortion of the part are negligible.

Part shape has to be considered. As the coating is formed by particles striking the surface, only those areas which permit free access will be coated evenly. Narrow holes, blind cavities and deep grooves cannot be coated satisfactorily. Sharp corners may become weak points and therefore give unsatisfactory service.

Flame-Plating is not recommended for metal-cutting edges because insufficient material is present to permit resharpening and service life is unsatisfactory. It is not suitable for use on parts such as power shovel teeth where inches of wear are permissible.

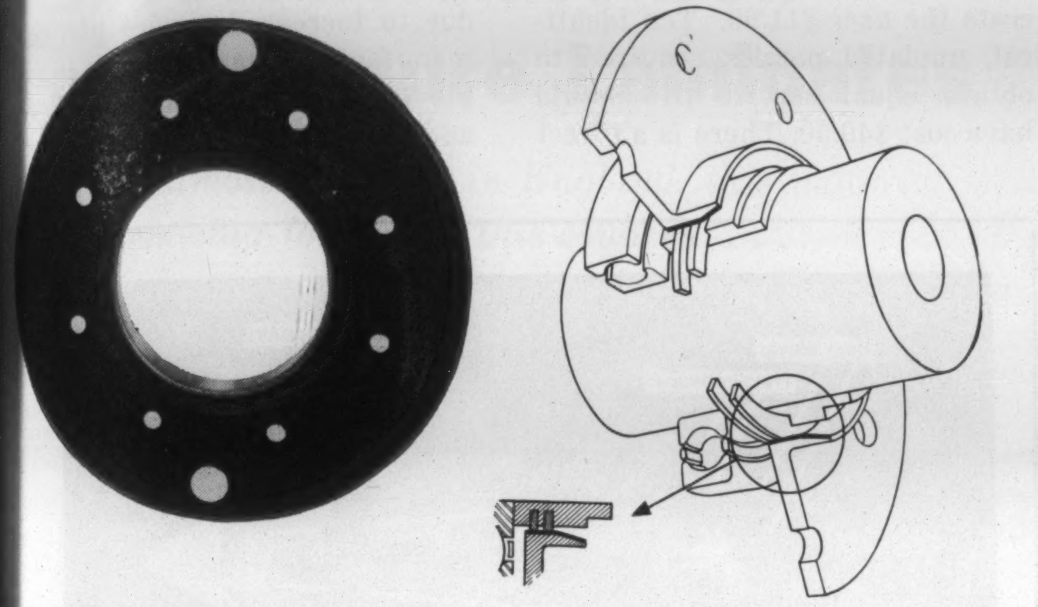
These tungsten carbide coatings are not generally considered corrosion resistant. Coatings are more resistant to acids than alkalis, but a neutral environment is desirable.

(Continued on p. 102)

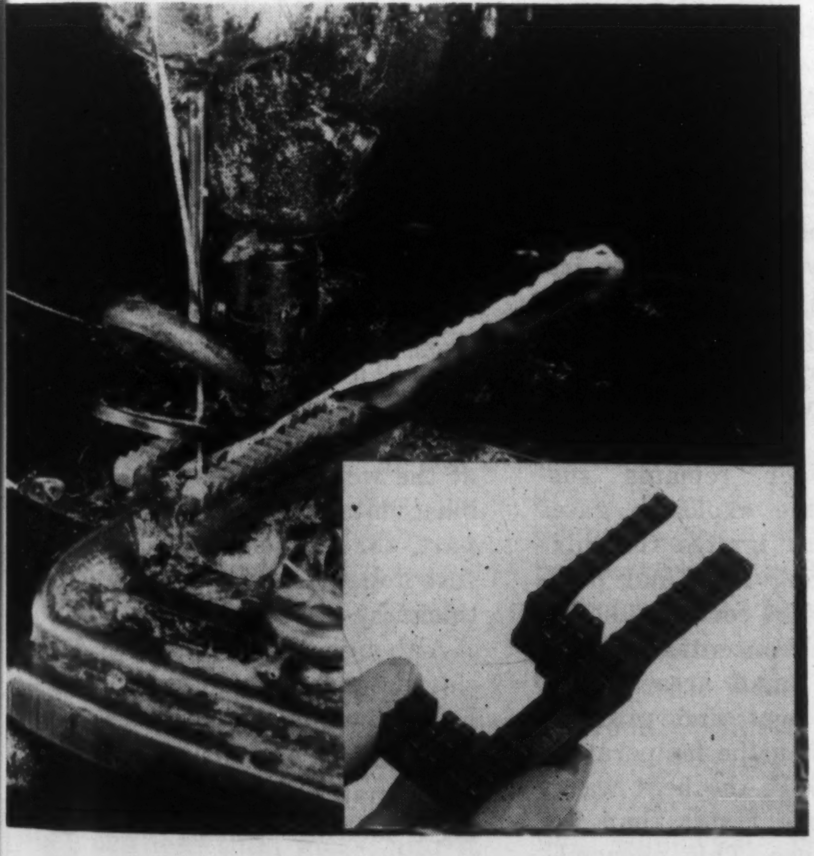
FLAME-PLATED TUNGSTEN CARBIDE COATINGS

COMPOSITION	92% tungsten carbide-8% cobalt
VICKERS HARDNESS NUMBER (300g LOAD)	1350 (average)
COATING THICKNESS, IN.	0.002 to 0.010
SURFACE FINISH: AS COATED AFTER FINISHING	120 to 125 microinches rms 0.5 microinches rms min
BASE METALS	Steels, cast iron, copper, brass, bronze, aluminum, molybdenum, nickel, magnesium, titanium and their alloys
SIZES OF PARTS, IN.	Round: Dia: 0.2 to 28 Length: 36 Flat: Length: 62 Width: 9 On flat areas to be finish ground, ¾ by 62. Where indentions of pass overlap are not objectional, limits of 9 in. width and 62 in. length apply.

Where Service is Severe

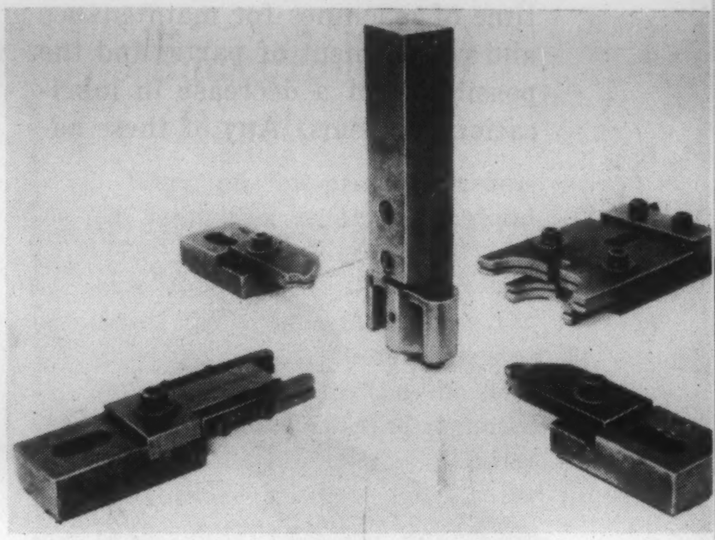


Fretting corrosion *limited the life of case hardened rotating ring compressor seals operating dry at 600 F in an aircraft turbine engine. Flame-Plated tungsten carbide parts average 150 to 200 hr in this service compared with about 25 hr for case hardened steel parts.*

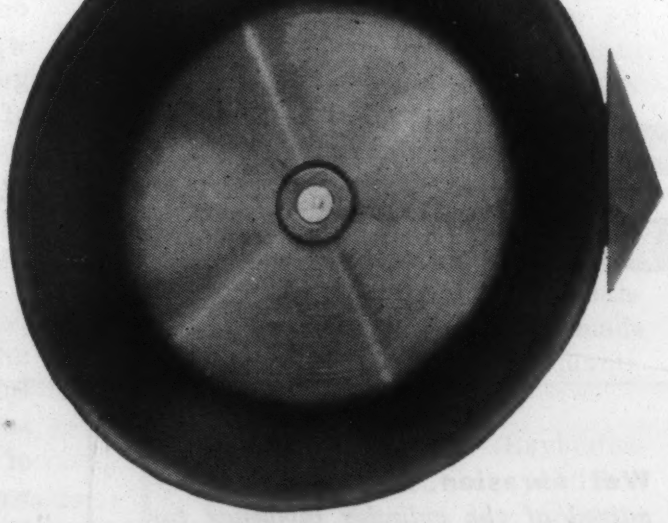


Gripping action *combined with wear resistance is required of these serrated feed dogs used in pushing cloth, plastics or other materials through a sewing machine.*

The service life of these parts has been increased more than 6 times that of unplated dogs by Flame-Plating the wearing surface with 0.002 in. of tungsten carbide. In this application, a feed dog costing $6 plus $4.60 for plating has a life equal to 6 identical unplated parts costing $36.



Abrasion resistance *is required on the surfaces and grooves of these wire forming mandrels. Tools coated with tungsten carbide by Flame-Plating had a service life 10 times that of the hardened tool steel mandrels used previously.*



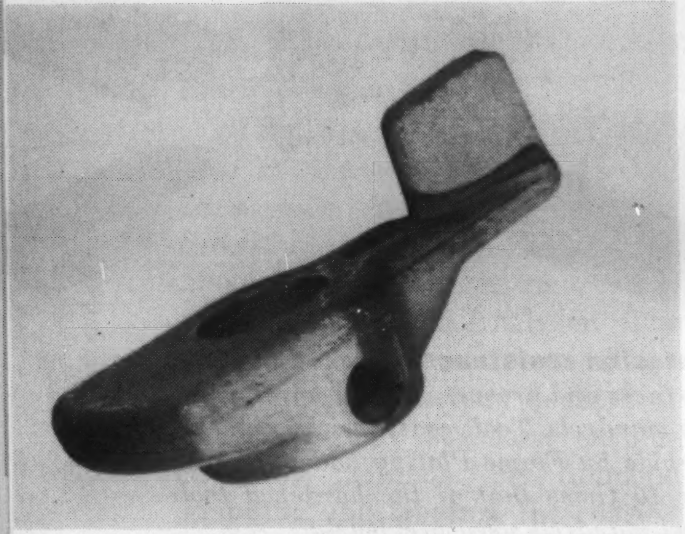
Hard to cut nonmetallic materials *such as rubber cause rapid dulling of knives. Disk-like skiving knives, used in the rubber industry to slice strips of rubber into designated widths, are beveled only on one side of the blade. Because of the abrasive action of the rubber, unplated knives required sharpening after each shift. A tungsten carbide coating Flame-Plated on the unbeveled side of the blade increased the service life of the tool 15 times and the blade is self-sharpening because the steel wears more rapidly than the coating.*

Economics

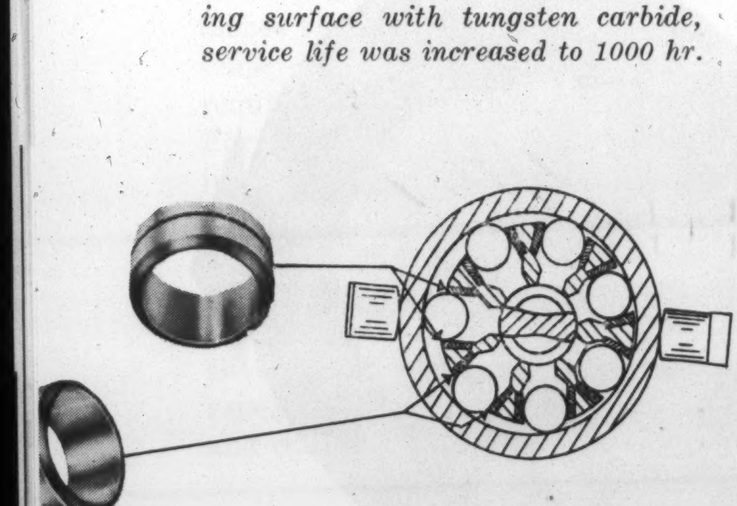
To arrive at the cost of Flame-Plating, the outlay in dollars must be balanced against the savings realized from increased service life, increased production with fewer rejects, decreased downtime of machines for maintenance and replacement of parts, and the possibility of a decrease in lubrication problems. Any of these advantages can offset the plating expense. For example:

The wear life of high-pressure water spray nozzles used in steel mills was increased 10 times by Flame-Plating these parts with tungsten carbide. A plated nozzle costs the user $11.90. Ten identical, unplated nozzles required to obtain equal service life would have cost $40.50. There is a direct saving of $28.60 in addition to the savings from decreased down-time.

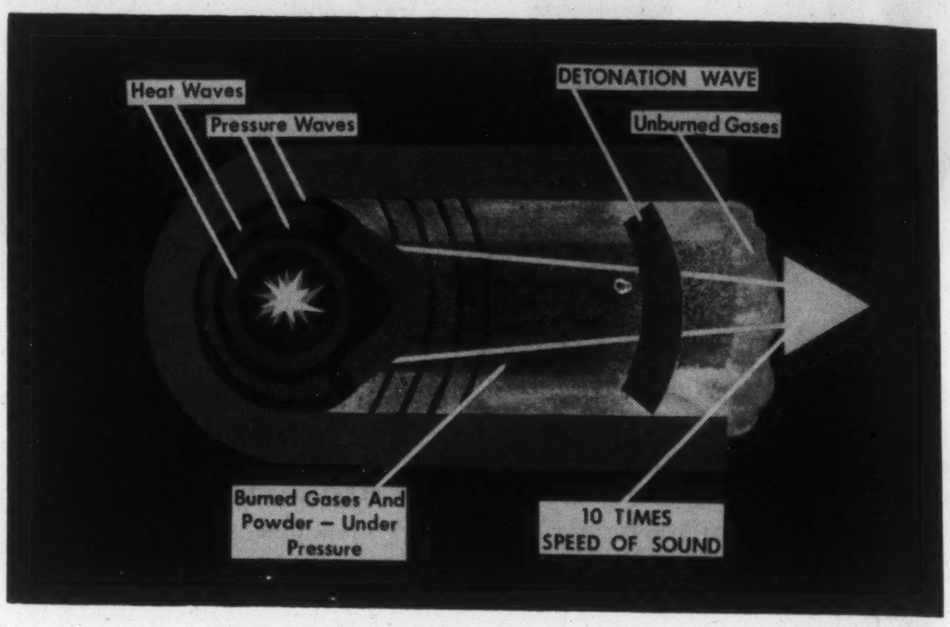
Tungsten carbide Flame-Plating of chain forming mandrels increased the service life 6 times over that of standard steel mandrels. Besides the obvious saving due to increased service life, one manufacturer has been able to cut his inventory in half, saving an additional $2000 per year.



Sliding abrasion *limited the life of forged aluminum rocker arms used in an aircraft heater mechanism. The parts are subjected to severe wear on an area which actuates a lever and had an average life of 200 hr in this service. By Flame-Plating the wearing surface with tungsten carbide, service life was increased to 1000 hr.*



Wet abrasion *resistance was required of the cylinder bushings for the ball pistons of a high pressure pump designed for long-time high-pressure service. At first, solid carbide inserts were used but the difference in expansion between insert and the steel ball and cylinder block caused failure when the temperature of the pump increased in normal operation. The problem was solved by replacing the carbide inserts with tungsten carbide coated steel bushings which had the same coefficient of expansion as the balls and cylinder.*



How the Process Works

Flame-Plating is a surfacing method in which particles of tungsten carbide are blasted onto the surface of a workpiece with a specially constructed gun. Briefly, the gun consists of a barrel and a mechanism for loading precise quantities of tungsten carbide powder, acetylene and oxygen into the firing chamber.

The powder remains suspended in the explosive gases until a spark ignites the mixture producing heat and pressure waves. The confining shape of the barrel concentrates these waves in a small area with a tremendous heat and pressure build up. When the temperature reaches 6000 F, the heat waves begin to move faster than the pressure waves. This phenomenon is detonation (see detonation diagram). The heat wave rips through the gas and powder mixture at ten times the speed of sound, completely burning the gases and building up pressure which reaches 10,000 psi in 0.003 sec inside the barrel.

When the detonation wave leaves the muzzle of the gun, it turns into a shock wave and dissipates into the air. The gases burst out carrying the tungsten carbide powder with them. The particles of tungsten carbide become molten and are hurled at supersonic velocities at the workpiece. As blast after blast hits the surface of the part, the particles build up and fuse together until the desired thickness is obtained.

Although the temperature inside the gun barrel reaches 6000 F, the temperature of the workpiece seldom exceeds 400 F even when materials with extremely high melting points, such as tungsten carbide, are being deposited. This means that precision and semi-precision parts and tools can be Flame-Plated without risking changes in metallurgical properties or physical dimensions.

Where you need heat resistance plus light weight, the answer might be . . .

Asbestos-Reinforced Low Pressure Laminates

Used for almost a decade in England, this material now looks promising for use in this country. . . . The reason: improved supply of the right kind of asbestos.

by John B. Campbell, *Associate Editor, Materials & Methods*

■ Low pressure asbestos-reinforced laminates have been used in the British aircraft industry for several years. Up to now they have not been used in this country, primarily because asbestos fibers in the size and quality required have not been readily available.

Within the past year or two, however, the outlook for asbestos has brightened considerably and suppliers claim that nonferrous spinning fiber will be available in ample quantities for the foreseeable future. This change in the supply picture should encourage designers to consider the potential advantages of asbestos laminates for certain applications. For example, although asbestos laminates seem to have somewhat lower room temperature strength than glass laminates, they have better strength retention at elevated temperatures and they are believed to have greater stiffness than glass laminates at both room and elevated temperatures.

Other advantages include high flame resistance, high acid resistance, high dimensional stability, and ability to bond readily to many materials. Asbestos itself costs much less than glass, and it can be combined with glass to produce laminates with improved properties.

Like any new material, low-pressure asbestos laminates must be studied carefully before their true range of usefulness can be determined. The remainder of this article gives more details on these materials and summarizes the data on properties now available.

Preimpregnated felts

The Durestos preimpregnated felts made by Turner Bros. Asbestos Co. consist of a carded web of mechanically opened fiber bundles — most of them ¼ to ⅝ in. long — uniformly impregnated with a partially cured thermosetting resin. The felts are produced in two sizes, 100 x 47 in. and 50 x 47 in., and in three nominal thicknesses, 1/64, 1/32 and 1/16 in., when cured to maximum density.

Four grades of Durestos felts are made. Highest strength is obtained with RA.1 which combines phenolic resin with long chrysotile fibers and cures to a medium brown color. The general-purpose grade is RA.2; its slightly higher phenolic resin content makes it particularly suitable for low pressure molding. Maximum acid resistance plus high strength is obtained with RA.3 which contains crocidolite fibers and phenolic resin and cures to a blue-black color. RA.4 has lower strength but somewhat better electrical properties than RA.1; it combines a spirit-soluble cresylic resin with long chrysotile fibers and cures to a yellow-brown color.

Durestos felts as supplied originally are pliable and tacky. They can be easily shaped but are relatively high in volatile content. In

Background of Development

Work on low-pressure asbestos laminates began in England shortly after World War II. The Royal Aircraft Establishment, the Bristol Aeroplane Co. and Turner Brothers Asbestos Co. cooperated in the development of a phenolic-impregnated asbestos felt known as "Durestos". Since then, at least three different types of aircraft wings have been made of Durestos and tested with good results. The material has been used for large-scale production of external fuel tanks. Good service records are also reported for Durestos ducts, fairings and pressure vessels.

Most of the work in this country has been done by Zenith Plastics Co., a leading producer of reinforced plastic aircraft parts. Zenith engineers visited England several years ago and, upon their return, set up a program to explore all phases of the use of these materials. The company now claims that it can produce airframe components of Durestos "conforming to the rigid requirements of our Armed Forces and Government agencies". However, it is not yet known whether Durestos felts will be made available in commercial quantities in this country.

More recently, Raybestos-Manhattan, Inc., has published technical data on low pressure laminates made with asbestos felts previously developed for high pressure laminating. This company has also developed a unique series of papers, including high-purity asbestos and a number of glass-asbestos mixtures, that may be useful in low pressure laminates. Although phenolics have been emphasized, some work has also been done with polyester, epoxy and silicone laminates.

time the felts become harder, first from loss of moisture and eventually by age-curing.

Because moldability of felts may vary considerably, depending upon age and storage conditions, it is usually desirable to condition the felts prior to molding. A wet felt can be dried or hardened for molding by heating it for a period of minutes to hours at 175 F. A dry felt (except RA.4 which has low water absorption) can be softened by soaking in water to restore moisture or, if molding is to follow immediately, by exposure to steam. A hard felt can also be softened by heat immediately prior to molding. Optimum condition of the felt depends to a great extent on the complexity of the molding and the molding pressure to be used. A curved or complex shape requires a wetter felt (or a higher molding pressure) than a flat laminate, and a higher molding pressure requires a drier felt to prevent outgassing.

Durestos has been molded successfully by matched dies, by the rubber bag vacuum technique, and with no applied pressure ("no-pressure molding"). A pressure of 560 psi provides maximum strength and dimensional stability but, according to Braham, 100 to 150 psi seems most economical for most applications. Molding temperature is about 325 F, and recommended molding time is about 20 min for a ⅛-in. section plus 5 min for each additional 1/16-in. Mold shrinkage is small.

Curing time can be reduced about 80% by applying an electric shock; the molding is heated to about 175 F between two copper platens, then subjected to a voltage of 230 a.c. A one-inch laminate pressed at 200 psi cures in about 20 min, the current flowing for only 5-10 min. The technique was discovered by chance at the Royal Aircraft Establishment and the exact mechanism is unknown.

Tooling requirements and finishing procedures are generally similar to those for other reinforced plastics. Carbide tips are recommended for machining because of the abrasiveness of the material. Hammered rivets are not recommended for joining because of the relatively poor impact strength of the material, especially in very thin sections (less than 1/16 in.).

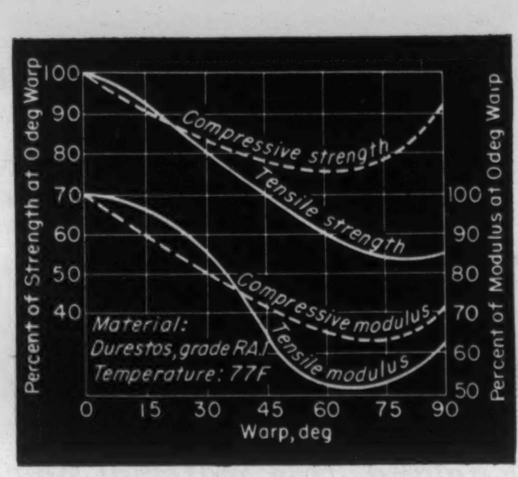


Fig 1—*Directional properties of asbestos-phenolic laminates.*

(Adapted from Braham)

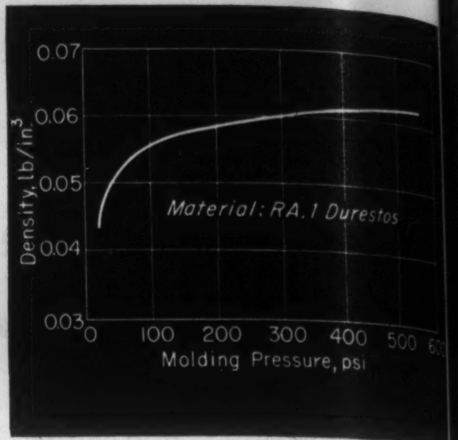


Fig 2—*Effect of molding pressure on density of asbestos-phenolic laminates.*

(Braham)

Other felts

The only other asbestos materials on which low pressure data have been published are the Pyrotex felts and Novabestos papers made by Raybestos-Manhattan.

The Pyrotex felts consist of chrysotile spinning fibers and, unlike Durestos, are not preimpregnated. Ordinarily they contain 2% of starch as a binder. They also may be obtained with no binder (suffix "NS"), although handling is extremely difficult, or with 3-5% of any phenolic (suffix "RB") or other resin desired. Moldings made from phenolic resin-bonded felts seem to have somewhat lower strength than those made from starch-bonded felts, although the difference in tensile and flexural properties does not exceed 10% for grade 9526.

There are many grades of Pyrotex felts, but data will be given for only two: 9526, the "highest strength" grade and 9372, a "general purpose" grade. Grade 9526 contains a minimum of 99% of extra-long nonferrous Canadian crude fibers, is about 10 mils thick, and weighs about 22 lb per 1000 sq ft. Grade 9372 is a blend of long crude and long spinning fibers containing a minimum of 85% asbestos, and is available in 8- and 10-mil thicknesses weighing about 14.5 and 17.0 lb per 1000 sq ft.

Other Pyrotex felts utilize long nonferrous South African crude fibers for good electrical properties, and blends of shorter spinning fibers for lower cost nonstructural applications. One new type is similar to grade 9372 except that it is reinforced with open-weave glass cloth in amounts up to 50% or more by weight. All of these felts have a bulk factor of about 3.0.

Raybestos-Manhattan has also produced experimentally a thick mat preimpregnated with phenolic resin. This mat may be 20 to 80 mils thick and has a bulk factor of 1.5 when pressed and cured at 200 psi.

Asbestos papers

The new Novabestos papers developed by Raybestos consist of single, chemically opened fibers and are free of many impurities comon to asbestos fibers. Because they consist of single fibers, these papers are smoother and more uniform in texture and fiber distribution than the usual asbestos papers, and they are more compressible and deformable when impregnated.

The new asbestos papers seem to be suitable for three different uses: relatively thin laminates; an interleaving for glass fibers, mats or fabrics to provide a cushioning effect; or a surfacing sheet where the relatively coarse surface pattern of asbestos felts or mats is undesirable.

Novabestos papers are made dry or preimpregnated. Dry papers are available as straight

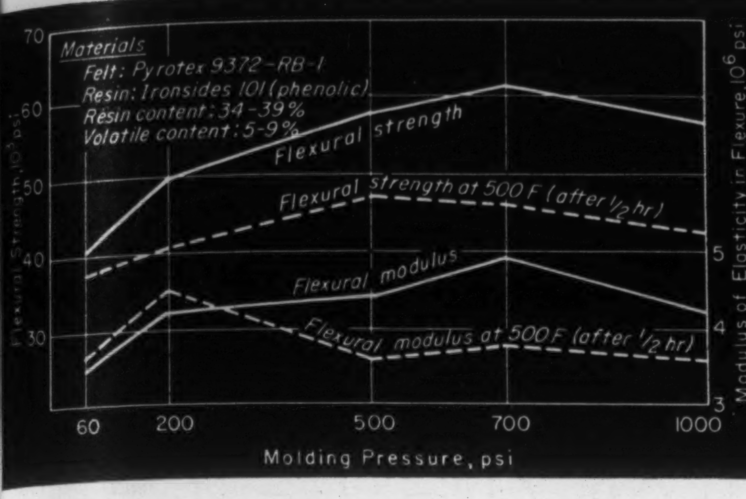


Fig 3—*Effect of molding pressure on flexural properties of asbestos-phenolic laminates.*

(Data from Raybestos-Manhattan)

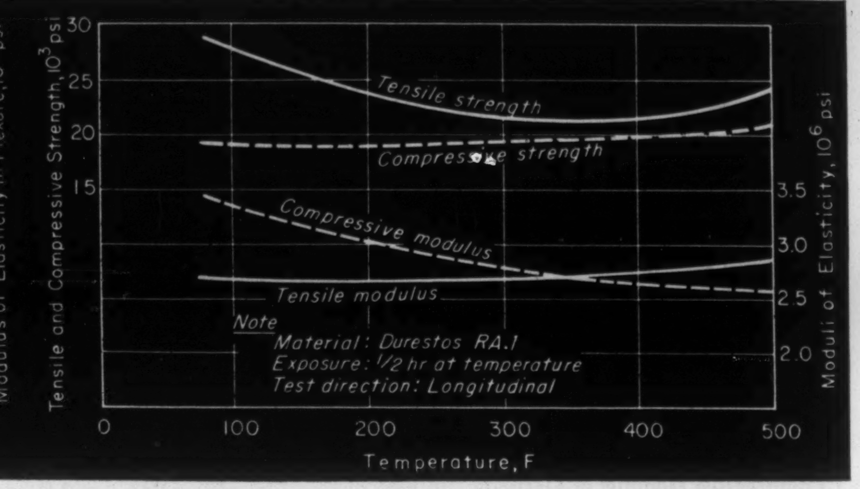


Fig 4—*Effect of brief exposures at elevated temperatures on properties of asbestos-phenolic laminates.*

(Adapted from Braham)

asbestos and in several grades containing short (about ½ in.) glass fibers in amounts up to 80% by weight. Organic content of these papers ranges from 2 to 10% and may be removed by heat or solvents. The higher-asbestos grades are available in thicknesses ranging from 2½ to 7 mils and weights ranging from 4 to 15 lb per 100 sq yd, whereas the higher-glass grades range from 5 to 25 mils in thickness and weigh from 7 to 28 lb per 100 sq yd. Dry papers have a bulk factor of 1.5 when cured at 15 psi and 2.0 when cured at 200 psi.

Standard preimpregnated papers may contain phenolic, polyester or epoxy resins. Recommended molding cycles are ½ hr at 260 F and 15 psi or more for phenolics; ½ hr at 300 F and 15 psi or more for polyesters; and ½ hr at 300 F and 200 psi for epoxies. Shelf life of unrefrigerated materials ranges from about one week for epoxies to three to six months for polyesters.

Cushioned glass warp

Because the use of asbestos as an interleaving with parallel glass fibers appears particularly promising, Raybestos has developed what it calls a "cushioned glass fiber warp." This material consists of closely packed parallel glass fibers (spacing ranges from 80 to 240 threads per in.) covered on both sides with a 3-or 4-mil Novabestos paper containing 15-20% glass; the material is fully bonded with polyester or epoxy resin and total thickness is 10-12 mils.

The cushioned glass warp is flexible and tough. It has a breaking strength of about 150 lb per in. of width. Considerable sideways stretchability allows it to conform readily to irregular mold contours. When laminated at low pressures (15-50 psi), preferably with the glass fibers under tension to keep them straight, it provides high directional strength at a moderate cost considering the relatively low glass content. The material seems to be well adapted to winding as a tape. Wound tubes are reported to have high burst strength and good leak resistance.

Properties

Some typical mechanical properties of asbestos-phenolic low pressure moldings are given in Table 1. Like other reinforced plastics, asbestos laminates have no definite yield point. The stress-strain curve is virtually straight except for a small curved portion immediately prior to failure.

Laminates made from parallel asbestos felts are anisotropic; transverse strength and stiffness are about two-thirds of corresponding longitudinal properties. Minimum properties occur in a direction somewhat less than 90 deg. (Fig 1). A similar variation of flexural properties is shown in Table 2 for Pyrotex laminates, although the data are too limited to show minimum properties. These latter data indicate that the directional variation of properties at elevated temperatures may be somewhat less than at room temperature.

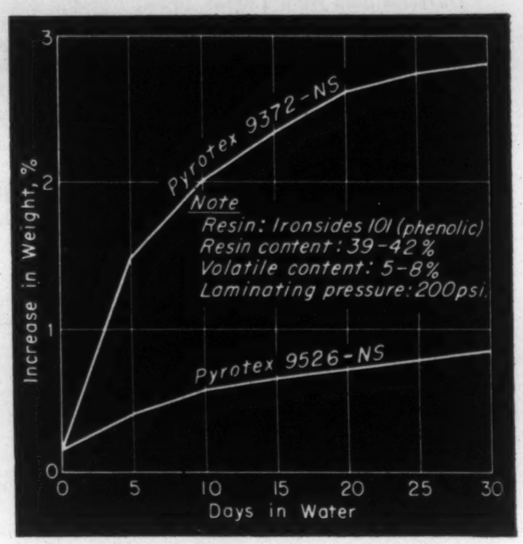


Fig 5—*Water absorption of asbestos-phenolic laminates.*

(Data from Raybestos-Manhattan)

Directional properties are also given in Table 3 which compares Durestos with phenolic-glass and shows the effects of combining the two materials. Other preliminary data indicate that asbestos interleavings tend to increase flexural strength and stiffness, edgewise compressive strength and, to a lesser extent, tensile strength. The higher properties appear to reflect a higher effective interlaminar strength believed to be due to the greater bonding ability and the considerably greater bonding surface area of the thinner asbestos fibers.

The increase in density of Durestos with increasing molding pressure is shown in Fig 2. Strength and stiffness properties of asbestos laminates appear to

TABLE 1—TYPICAL PROPERTIES OF ASBESTOS FELT-PHENOLIC RESIN LAMINATES[a,b]

MATERIAL / PROPERTY	TOP QUALITY GRADES			MORE ECONOMICAL GRADES		
	Durestos RA. 1		Pyrotex 9526-RB-1[c]	Durestos RA. 2		Pyrotex 9372-RB-1[c]
	Molded at 14 psi	Molded at 100 psi		Molded at 14 psi	Molded at 100 psi	
Flexural Strength, 10^3 psi	—	—	55.0	—	—	45.0
Flexural Modulus of Elasticity, 10^6 psi	—	—	4.5	—	—	3.5
Tensile Strength, 10^3 psi	18.0	28.0	50.0	8.5	18.0	30.0
Tensile Modulus of Elasticity, 10^6 psi	1.8	3.1	5.0	1.7	2.6	3.5
Compressive Strength (edgewise), 10^3 psi	10.0	20.0	30.0	10.0	18.0	28.0
Compressive Modulus of Elasticity, 10^6 psi	—	3.5	4.3	—	—	—
Izod Impact Value, ft-lb/in.	2.4	3.2	5.2	1.3	2.4	2.6
Shear Strength, 10^3 psi	9.0	17.0	—	8.0	14.0	—

[a] *Durestos data from Turner Bros.; Pyrotex data from Raybestos-Manhattan and* Braham

[b] *Longitudinal properties. Data for Durestos and Pyrotex should not be compared, since the molding and curing cycles differed for the two materials. Pyrotex moldings were given an elaborate post-cure designed to produce maximum strength; though not specified, the curing cycle for the Durestos moldings was probably much shorter and, consequently, more typical of commercial practice for all but the most critical parts.*

[c] *Resin content: 37-40%. Pressed 30 min at 200 psi and 300 F to thickness of ⅛ in., specific gravity of 1.6-1.7. Post cure: 24 hr ea at 250, 300 and 350 F, plus 18 hr at 400 F.*

TABLE 2—DIRECTIONAL PROPERTIES OF ASBESTOS-PHENOLIC LAMINATES[a,b]

PROPERTY / ANGLE TO WARP	Flexural Strength, 10^3 psi		Flexural Modulus of Elasticity, 10^6 psi	
	Room Temp	500 F (after ½ hr)	Room Temp	500 F (after ½ hr)
0	55.0	38.0	37.0	30.0
45	48.5	28.0	32.5	18.0
90	35.5	25.0	18.5	15.0

[a] *Adapted from Raybestos-Manhattan data.*

[b] *Consisting of Pyrotex 9526-NS felt and 39-44% of Borden AL-5271 phenolic resin. Volatile content: 5-9%.*

increase at a correspondingly rapid rate up to 100-200 psi, much more slowly up to 500-700 psi, and virtually not at all beyond that point. For example, one set of laminates made with resin-bonded Pyrotex 9526 and 38-42% of a phenolic resin at molding pressures varying from 200 to 700 psi ranged only from 1.6 to 1.7 in specific gravity, from 55,000 to 60,000 psi in flexural strength, and from 4.2 to 5.0 x 10^6 psi in flexural modulus. These laminates, laid up in parallel, were pressed and post-cured to thicknesses of 40 to 150 mils. Differences in properties obtained by vacuum molding and by molding at 100 psi are shown in Table 1. Although a molding pressure of 560 psi is said to provide maximum density in Durestos, Fig 3 indicates that further improvement in flexural properties of some Pyrotex laminates could be expected at molding pressures up to about 700 psi.

Asbestos laminates have considerable resistance to heat and flames. Durestos RA. 1 is said to be "unaffected" by heating to 350 F in air and to much higher temperatures in the absence of air. When pressed to maximum density, its blister temperature is about 450 F. Asbestos itself begins to lose its water of crystallization rapidly at temperatures over 900 F but the effect on laminates is not known. However, it is claimed that laminates exposed for periods ranging from seconds to minutes at temperatures up to 4000 F have remained intact and have retained strength and stiffness. Retention of tensile and compressive properties of Durestos laminates after brief exposure at temperatures up to 500 F is shown in Fig 4. Effects of much longer heating times and of heating as high as 700 F on the flexural properties of Pyrotex laminates are shown in Table 4.

Water absorption of phenolic laminates made with two grades of Pyrotex felt is shown in Fig 5. With the exception of electrical grade RA.4 which has low absorption, Durestos is reported to show highly variable water absorption behavior in all but very thin sections.

Durestos is claimed to resist successfully all chemical reagents except hydrofluoric acid, nitric acid and strong (more than 5%) caustic alkaline solutions. The acid-resistant grade, RA. 3, is recommended where severe exposures to mineral acids are involved. No cracking, crazing or delamination occurs in organic acids or solvents.

Little data are available on polyester-asbestos laminates. However, one series of laminates made with a low-cost resin-bonded Pyrotex felt showed flexural strengths ranging from 25,000 to 32,000 psi and flexural moduli

TABLE 3—ASBESTOS LAMINATES COMPARED WITH GLASS AND ASBESTOS-GLASS LAMINATES[a]

	Angle to Warp, deg	Room Temperature				500 F—after ½ hr			
		Ten Str, 10^3 psi	Ten Mod, 10^6 psi	Comp Str, 10^3 psi	Comp Mod, 10^6 psi	Ten Str, 10^3 psi	Ten Mod, 10^6 psi	Comp Str, 10^3 psi	Comp Mod, 10^6 psi
Glass-Phenolic (181 cloth, Volan A finish, 0.120 in. thick)	0 or 90	43.4	2.75	43.2	3.66	30.6	2.60	27.0	3.32
	45	21.0	2.03	24.0	2.20	15.3	1.73	18.3	1.65
Asbestos-Phenolic (Durestos RA. 1, 0.105 in. thick)	0	28.6	2.70	19.2	3.47	24.3	2.87	20.6	2.55
	45	20.0	1.72	15.1	2.56	15.3	2.14	16.8	2.26
	90	16.1	1.71	17.2	2.53	12.1	1.75	16.7	1.65
50:50 Combination (glass-phenolic and glass-asbestos, 0.125 in. thick)	0	29.4	2.81	32.0	3.42	19.3	2.74	23.0	2.95
	45	21.0	1.80	25.7	2.42	15.4	—	20.6	—

[a] *Data from* Braham.

TABLE 4—RETENTION OF FLEXURAL PROPERTIES AT ELEVATED TEMPERATURES[a,b]

	% Retained Flex Str	% Retained Flex Mod
300 F after 200 hr	87	90
500 F after 100 hr	72	86
700 F after ½ hr	60	75

[a] *Data from* Rosato.

[b] *Resin-bonded Pyrotex 9526 with 37-40% phenolic resin. Laminates made by pressing parallel plies 30 min at 200 psi and 300 F to thickness of ⅛ in., specific gravity of 1.6-1.7. Post-cure: 24 hr ea at 250, 300 and 350 F, plus 18 hr at 400 F.*

TABLE 5—FLEXURAL STRENGTH OF SILICONE-ASBESTOS LAMINATES[a,b]

MATERIAL / PROPERTY	Pyrotex 9526-NS		Pyrotex 9529-NS[c]	
	Cured 40 hr at 482 F	Cured 300 hr at 482 F	Cured 40 hr at 482 F	Cured 300 hr at 482 F
Flexural Strength at Room Temp, psi	31,300	29,700	34,800	10.700
Flexural Strength at 500 F after ½ hr, psi	14,400	16,400	32,900	16,000

[a] *Data from* Rosato. *Work by Dow Corning Corp. Tests in accordance with Federal Spec. L-P-4066.*

[b] *Containing 45-50% DC-2106 resin. Made by pressing 25 parallel plies for 30 min at 300 psi and 350 F to thickness of ⅛ in. and specific gravity of 1.7-1.8. Post-cure: 16 hr at 194 F; 2 hr ea at 257, 302, 347, 392 and 437 F; plus indicated time at 482 F.*

[c] *Style 9526 modified by addition of open-weave glass cloth.*

ranging from 1.6 to 2.0 x 10^6 psi. These laminates were laid up parallel, contained 40 to 60% resin, and were pressed at 15 to 50 psi to specific gravities ranging from 1.45 to 1.55.

Preliminary data on silicone-asbestos laminates are summarized in Table 5. To determine the effect of higher temperatures, Dow Corning Corp. exposed laminates cumulatively one hour each at 100-deg intervals of temperature from 400 to 1000 F inclusive. Room temperature flexural strength of laminates thus exposed was 13,400 psi.

Properties of thin laminates made from Novabestos papers have also been determined. The following ranges of properties were obtained for laminates utilizing papers containing 60 to 80% glass and 60 to 70% of a phenolic or polyester resin, laid up parallel, and molded at 15 to 200 psi:

Specific gravity	1.2-1.5
Tensile strength	20-30,000 psi
Tensile modulus	1.5-2.5 x 10^6 psi
Flexural strength	24-40,000 psi
Flexural modulus	1.4-2.0 x 10^6 psi
Compressive strength	24-45,000 psi

Properties of laminates made from cushioned glass fiber warps impregnated with polyester and epoxy resins are given in Table 6.

TABLE 6—PROPERTIES OF CUSHIONED WARP LAMINATES[a,b]

RESIN / PROPERTY	Polyester[c] (Atlac 382)	Epoxy[d] (Modified Epon 828)
Ten Str, psi	60–70,000	70–90,000
Ten Mod of Elast, 10^6 psi	3.0–3.5	4.0–4.5
Flex Str, psi	70–90,000	90–110,000
Flex Mod of Elast, 10^6 psi	2.5–3.5	3.0–4.0
Comp Str, psi	40–50,000	50–60,000

[a] *Data from Raybestos-Manhattan.*

[b] *Composition: 48-52% resin, 18-22% Novabestos paper (15-20% glass), 28-32% glass warp. Made by pressing 9-10 parallel plies at 10-50 psi to thickness of ⅛ in., specific gravity of 1.6-1.7. Warps stretched during curing.*

[c] *Cured ½ hr at 300 F.*

[d] *Cured 1 hr. at 350 F.*

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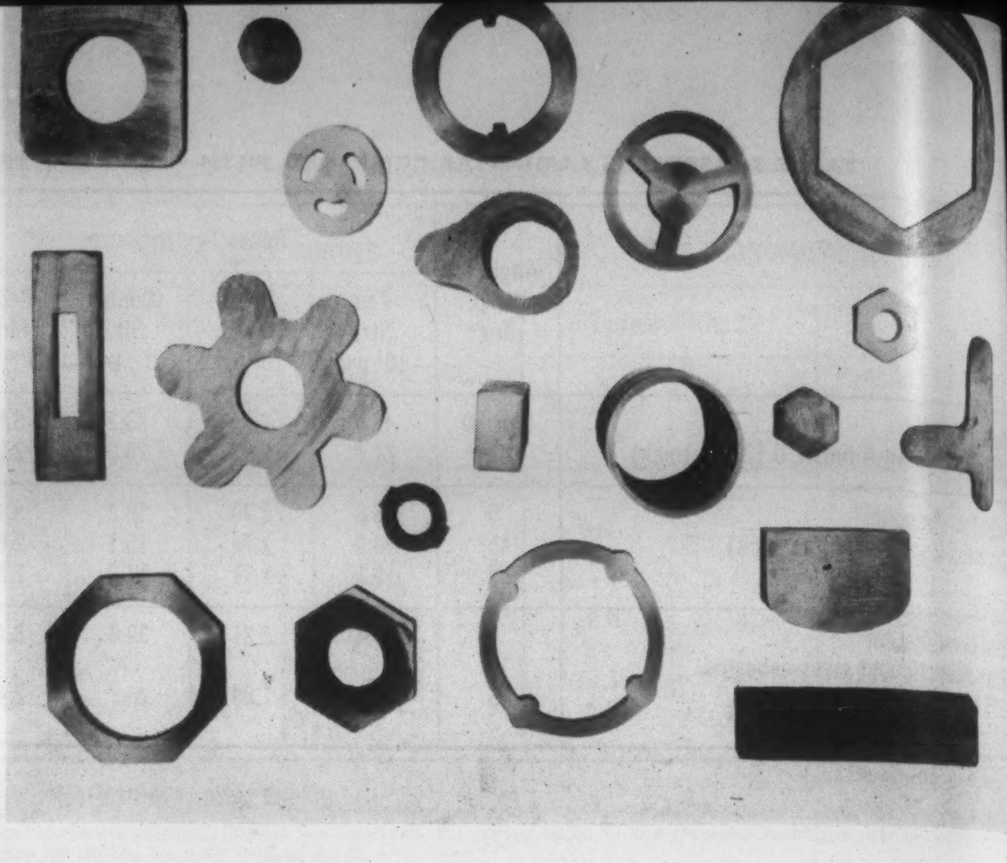


For use in the automotive, railroad, aircraft, and general industrial field . . .

Continuous Cast Bronze Shapes

Because shapes can be produced close to required contours, significant cost savings are realized.

by G. D. Storm, *Superintendent of Continuous Casting, American Smelting and Refining Co.*

■ The advantages of producing stock material as close to finished size as possible have been recognized for many years. Such a procedure minimizes machining with resulting cost savings and reduction of scrap losses. Various processes are in use to accomplish this objective. Shapes are produced by casting, rolling and extrusion, for example. Of these, continuous casting has entered the field of production of various alloys which are usually available only as sand, permanent-mold or centrifugal castings. Included in this group are the tin bronzes widely used in bearings, bushings and structural parts.

Alloys and forms available

The Asarco process is the only continuous casting method used commercially for the production of finished copper-base alloy stock. Alloys now in production include the standard tin-bronzes which are employed for bearings, bushings and structural parts. Compositions are given in a table. These alloys, formerly available only in small sand, permanent-mold or similar castings, are now available in a form equivalent to long mill rods, tubes and special shapes. Although these products are cast to size and straightening is the only finishing operation, dimensional control is excellent, and the mill lengths produced are suitable for screw machine use.

Properties

In the case of complex alloys such as the leaded tin bronzes, dispersion of the tin-rich and globular lead secondary phases present in the casting has a marked effect on the mechanical properties. The rapid freezing of the alloy during continuous casting results in much greater uniformity of structure than can be obtained by conventional foundry methods. As a result, the quality is more uniform and the mechanical properties are greatly improved.

The Alloys

Sizes

Properties

How it's Done

The Asarco continuous casting method is a gravity-fed bottom-pouring procedure which yields sound castings because the main bath acts as a large head and riser to feed the casting and prevent shrinkage. Soundness is promoted also because gases liberated during solidification escape through the molten bath, and foreign matter entering the system floats to the top. Oxidation is prevented by the use of nitrogen as a cover gas. As a result, high density alloys are produced.

A particular advantage of the casting method arises from the use of expendable graphite dies having an average life of 24 hr. Dies are produced quickly and at lower cost than metal dies used in other continuous casting processes. Consequently, small quantity runs of special sizes and shapes are commercially practical.

Type*	S. A. E. No.	Nominal Composition, %			
		Cu	Sn	Pb	Zn
89-11-0-0	65	89	11	0	0
88-10-2-0	63	88	10	2	0
88-10-0-2	62	88	10	0	2
88-8-0-4	620	88	8	0	4
88-6-1.5-4.5	622	88	6	1.5	4.5
85-5-5-5	40	85	5	5	5
85-5-9-1	66	85	5	9	1
83-7-7-3	660	83	7	7	3
80-10-10-0	64	80	10	10	0
80-2.5-10-7.5	—	80	2.5	10	7.5
75-5-20-0	—	75	5	20	0

* *Code indicates composition in the following order: copper-tin-lead-zinc.*

Rod: $\frac{13}{32}$ to $9\frac{1}{8}$ in. dia

Tube: 1 to $9\frac{1}{8}$ in. o.d. $\frac{15}{32}$ in. min i.d.

Tube wall: For o.d. to 2 in., $\frac{5}{32}$ in. min

For o.d. from 2 to $9\frac{1}{8}$ in., 9% of o.d.

Length: 12 ft standard, longer can be supplied

Tolerances: +0.004 to −0.006 in. on o.d. Tube concentricities within 1.5% of wall thickness

Four quills, 14-9/16 in. long, *for drilling machines are made from this 60 in. length of stock. The outside-round, inside-hexagon shape closely approximates that of the finished part. Production cost with new material was reduced from $158 to $73.*

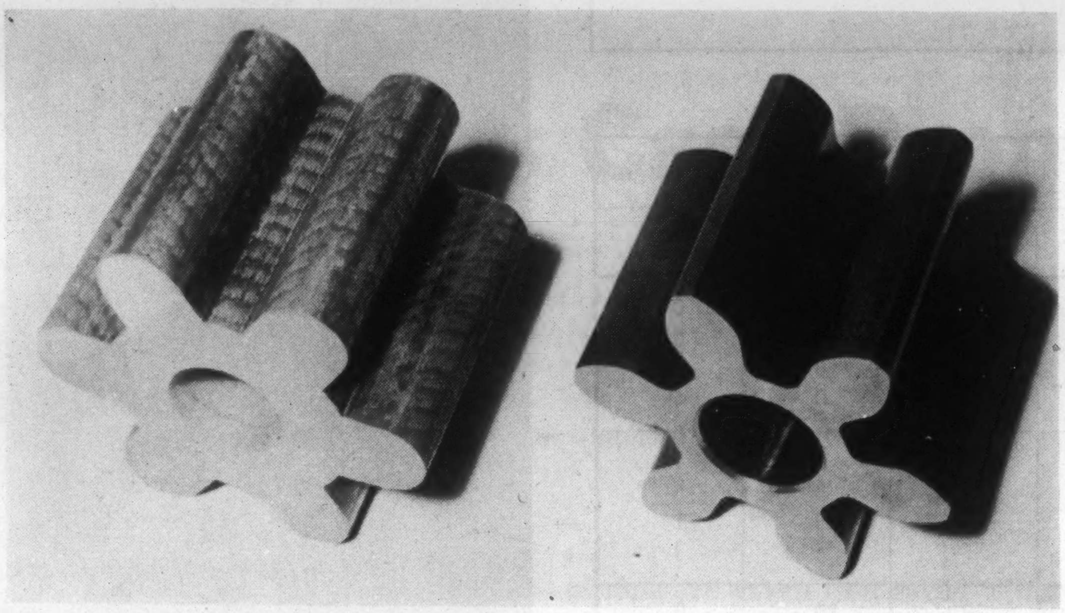
(Sprague & Henwood, Inc.)

Nominal Comp, %	88-10-0-2		85-5-5-5		83-7-7-3		75-5-20-0	
Casting Method	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast
Tensile strength, psi	53,000	50,000	45,000	36,400	44,000	40,400	30,000	26,900
Yield strength, psi	25,000	20,000	21,400	16,900	27,000	19,500	18,000	15,800
Elong (2 in.), %	30	25	28	35	16	39	13	17
Rockwell Hardness	B57	—	B43	—	B46	—	B16	—
Brinell Hardness	86	76	72	49	72	65	57	45
Impact strength, ft-lb	25.5	8.7	20.7	12.0	12.3	9.3	6.2	5.5
Fatigue strength, psi	24,500	13,000	16,000	8500	20,000	12,000	16,000	12,500

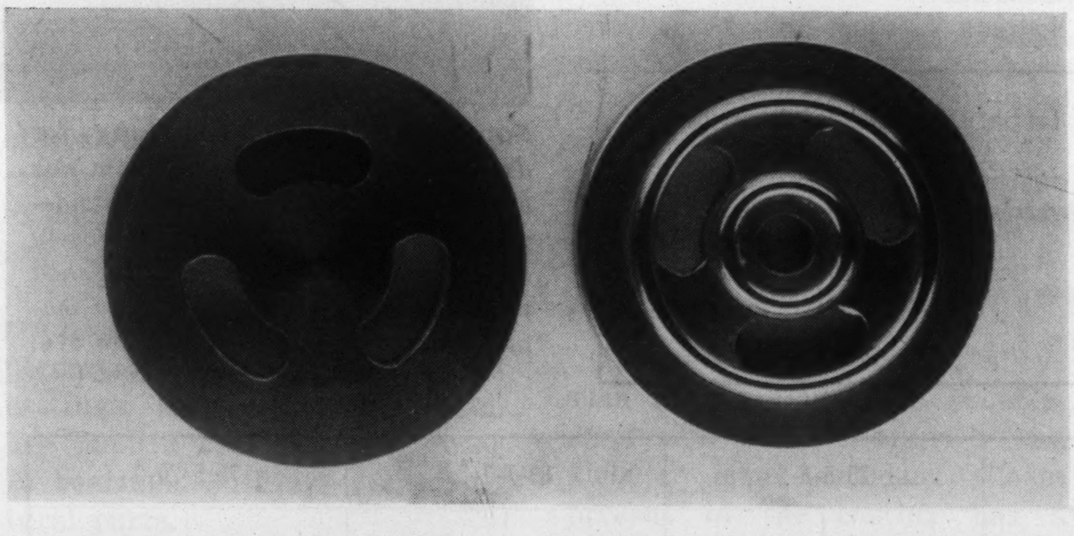
Comparative properties of several typical alloys produced by continuous casting and by sand casting are given in a table. The continuous cast materials are harder and stronger than the sand castings while the ductility as measured by elongation is lower. The continuous cast alloys show a marked increase in fatigue strength probably resulting from their freedom from stress raisers such as porosity and shrinkage defects. In most of the materials, impact strength is also improved greatly.

Applications

These bronzes are used for a wide variety of bearing applications in the automotive, aircraft, railroad and general industrial field in competition with similar alloys cast by more conventional methods. However, a field in which they are finding increasing application is the production of parts where advantage can be taken of the ability to produce special shapes requiring a minimum of machining to finish. Some of these shapes are shown in an accompanying illustration. They are used for the production of an ordnance part, a sliding way in a dam gate, a thread guide for textile machinery, gears, slide valve bushings for an air brake, valve seats and seat rings and connecting rods. The particular alloy selected is determined by service requirements. Some applications of specific alloys follow.

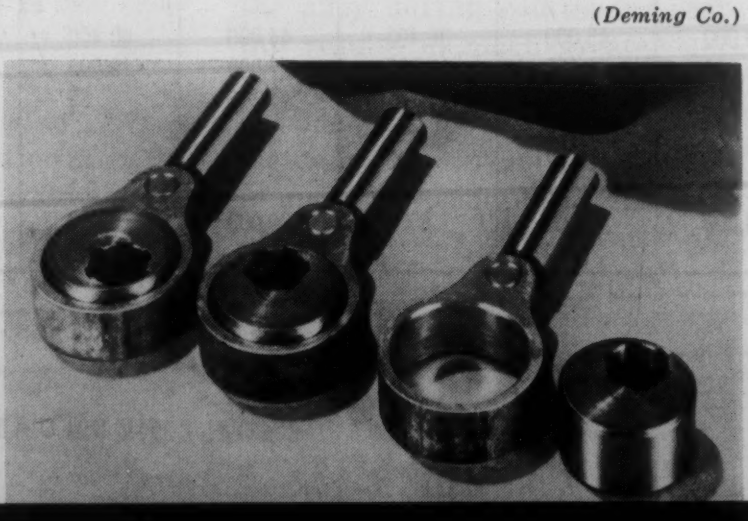


Continuous cast bronze stock *(left) as supplied to the Hale Fire Pump Co. for pump rotors. Only one rough and one fine cut are made to finish the teeth.*



Valve seat *(right) is produced from continuous cast stock (left) at a higher production rate and with lower scrap losses than resulted with the sand cast stock used previously.*

(Deming Co.)



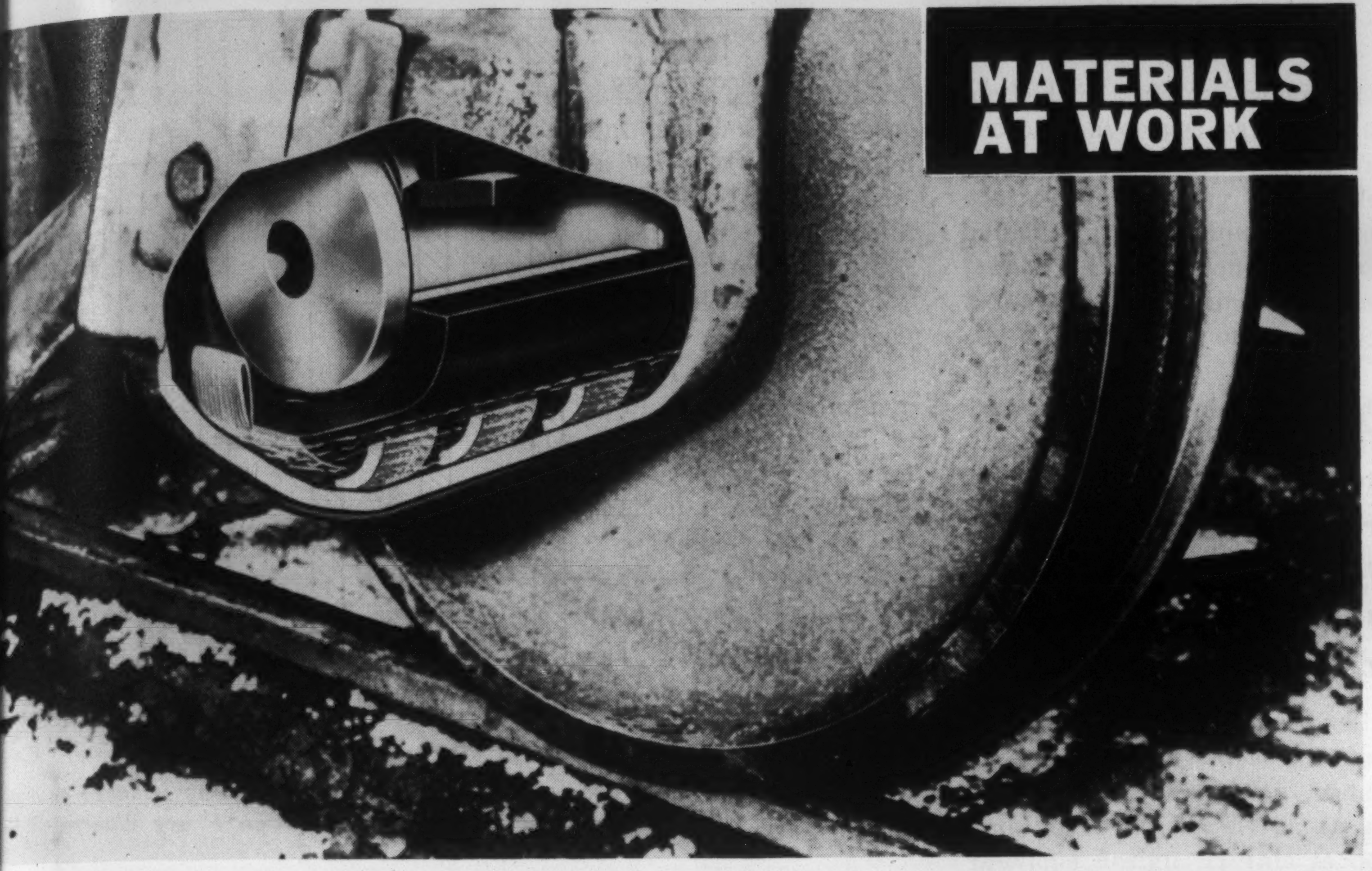
Keyhole shape *continuous cast bronze is used in the production of oil pump connecting rods by Bendix Aviation Corp.*

A part called a "quill," serving as a power transmission element in a core drilling machine, bears rotary and reciprocating loads at the same time. This part, a tube with a hexagonal center hole, was purchased as a machined casting from an outside source by the producer of the drilling machine. Converted to a continuous casting of 88-10-0-2 bronze, stock was supplied in a shape closely approximating the final part. The hexagonal inside section required only a light broaching operation while the outside surface was completed with six machine cuts. The change resulted in a saving of $85 per part.

Rotors for fire engine priming pumps have been made for many years from sand cast 88-10-0-2 bronze blanks. Three of these six-tooth rotors are required for each engine, two in the centrifugal pump and one in a rotary booster pump. Stock is now supplied in a continuously cast shape which closely approximates the finished rotor. Finishing requires only two machining cuts, one rough and one fine.

Continuously cast 75-5-20-0 bronze produced in a special keyhole shape is in use for the mass production of oil-pump connecting rods. The shape replaces individual sand castings of the same alloy at a substantial saving of material since basic dimensions are close to the required size.

A valve seat for a shallow well pump was sand cast using 85-5-5-5 bronze. Converting to a continuous cast shape of the same analysis permitted faster machining since the new form could be machined on automatics instead of hand turret lathes, reduced scrap and resulted in fewer rejected parts.

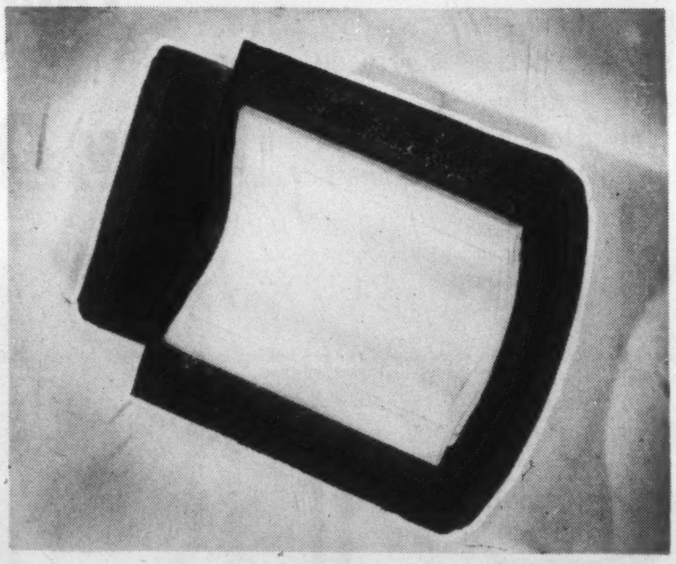


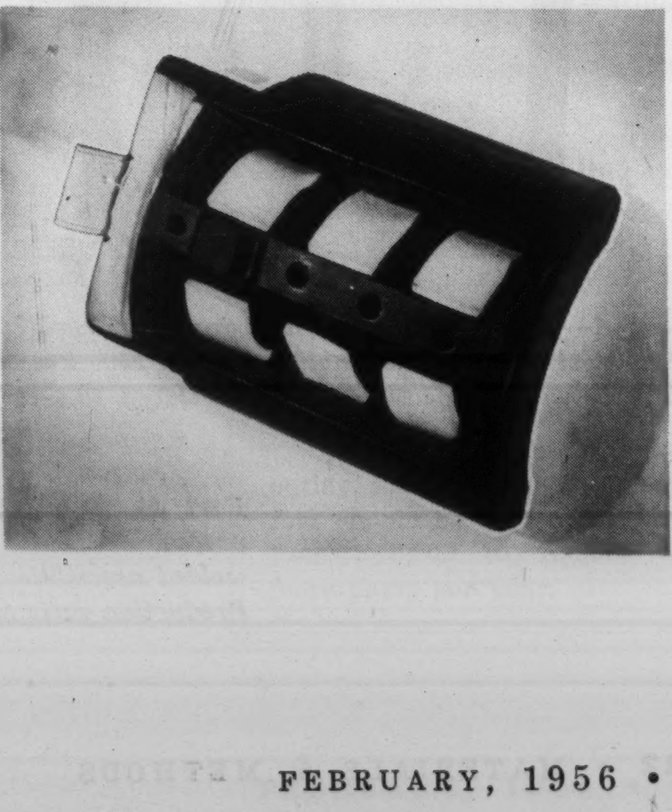
MATERIALS AT WORK

Felt and neoprene cut hot boxes

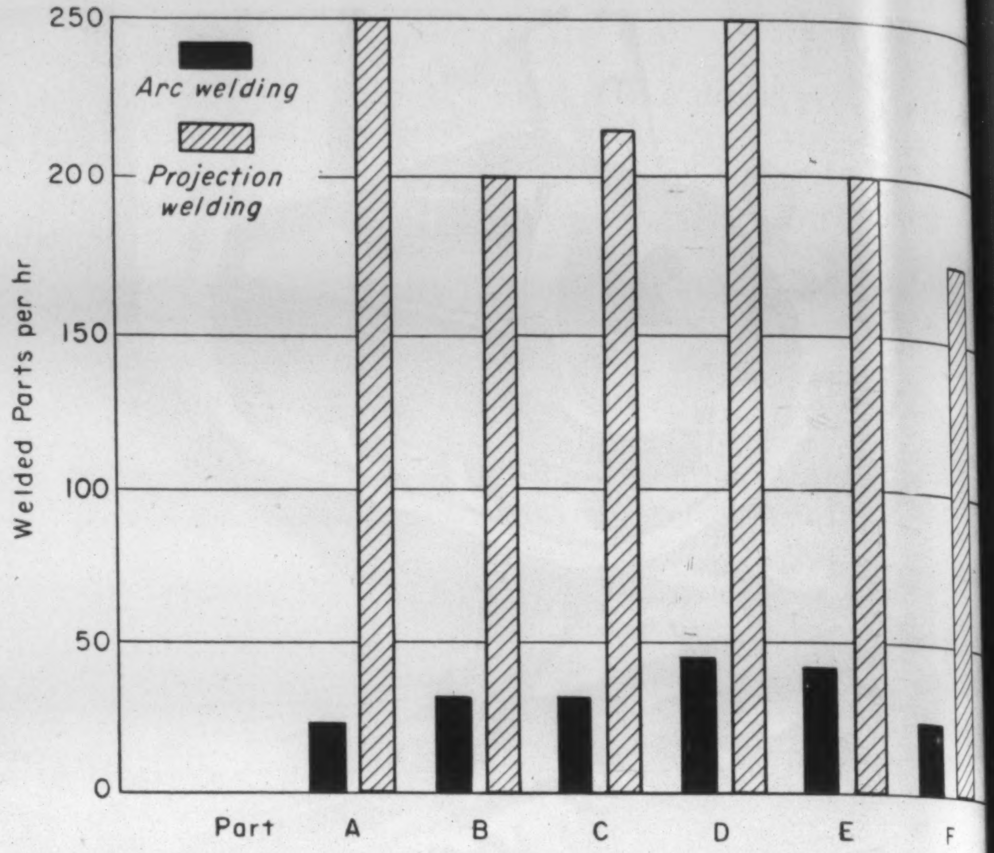
Use of felt wicks and neoprene sponge is said to effectively cut incidence of hot boxes which are said to be the railroads' most costly freight car operating problem. Conventional journal boxes are packed with cotton waste which holds oil and lubricates the bearings. About 70% of the hot boxes that occur are said to be caused by some of this waste being carried up between the bearing and axle. The new type of lubricator, developed by U. S. Rubber Co., does away with cotton waste entirely.

A highly absorbent felt wick pad is fitted to the top surface of the sponge neoprene (top). In operation it is always in contact with the underside of the journal. Six wick ends pass through slots in the sponge (bottom) down into a reservoir of oil in the bottom of the journal box. In addition to oil feed by wicking, each vertical movement of the journal compresses the sponge and forces oil up to saturate the felt pad. The neoprene sponge retains its resiliency and strength after long service under conditions of high temperature, abrasion and constant exposure to oil.





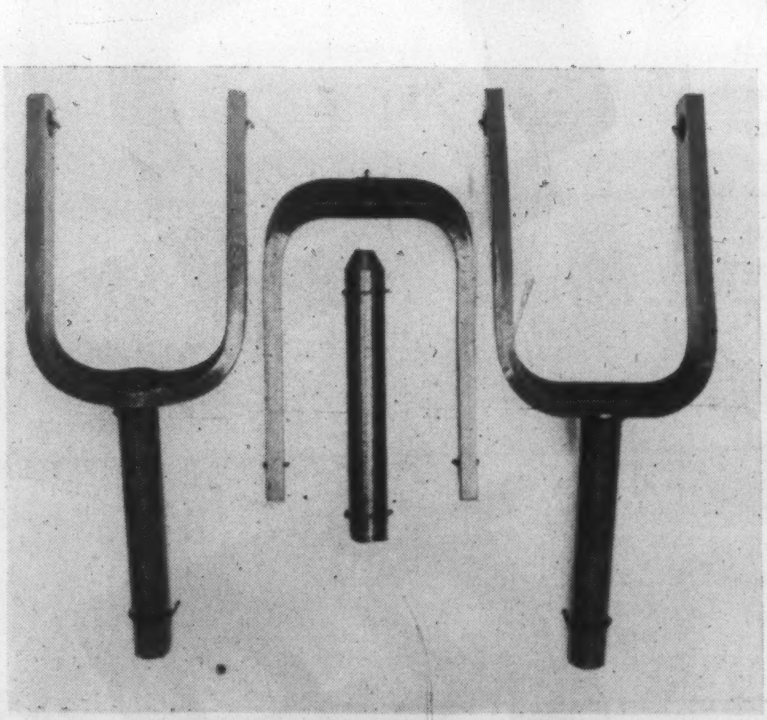
At Deere & Co.
some 250 redesigned parts
resulted in:
Increased production rate
Uniformity of product
Improved appearance



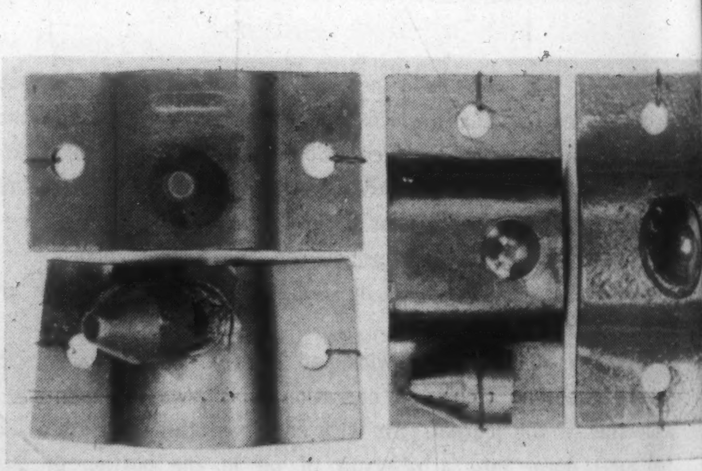
Comparison between arc welding and production welding is based on a year production of 463,000 assemblies. Parts A through F are illustrated bel

This chart shows . . .

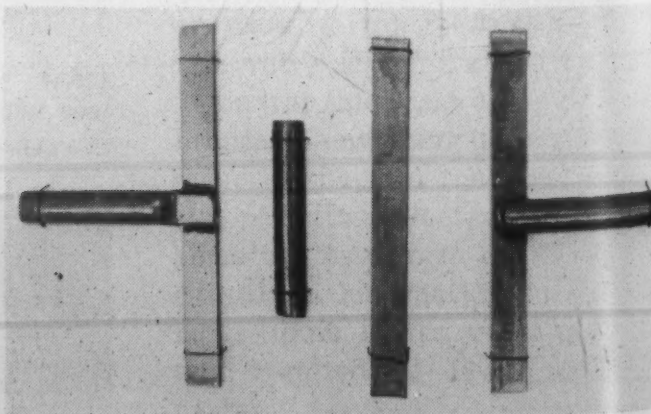
How Designing for Projectio We



Part A—Gage wheel yoke, line projection weld (SAE 1055 steel); welded assemblies per hr, 250. Production ratio between projection and arc welding 10.4 to 1.



Part B—Adapter, button in strap (SAE 1020); welde assemblies per hr, 215. Production ratio, 6.2 to 1.



Part C—Stub beam, natural projection weld (SAE 1045); welded assemblies per hr, 215. Production ratio 6.5 to 1.

Welding Can Lower Costs

by **C. H. Burgston,** *Welding Div. Supervisor, Materials Engineering Dept., Deere & Co.*

■ Where arc weldments, forgings or castings lend themselves to design for resistance projection welding, substantial cost savings can generally be realized. During the past four years for example, some 250 parts used in the manufacture of farm implements and tractors were redesigned and fabricated by projection welding. These parts would be classified in general as heavy section projection weldments.

The accompanying chart compares the production welded assemblies per hour obtained by the projection welding process and by the previous arc welding method. More recent production figures show even greater differential ratios. In addition to high weld production per hour which is reflected in decided cost savings, there is a marked drop in welding man-hours required when using projection welding. This is important in shop production planning.

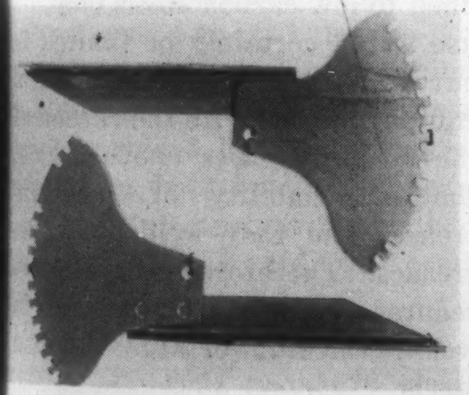
The 463,000 assemblies that were arc welded required 17,350 welding man-hours while the same production when projection welded was produced in 2770 welding man-hours.

Individual part costs by both methods of welding are not shown because average earnings and methods of figuring costs vary considerably among the various manufacturers. However, comparative production per hour figures are given, and these facts can be evaluated on a basis of current costing methods.

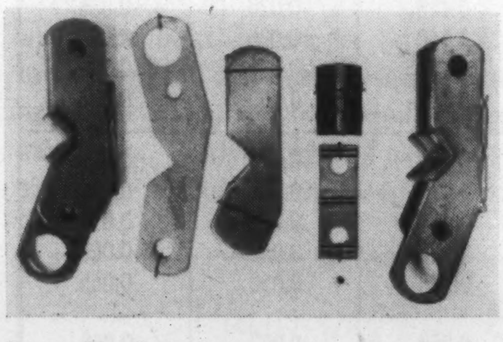
Designing for projection welding

Important from a part design standpoint is that several projection welds can be made with one stroke of the welding machine ram. Welds can also be spaced closer together than in spot welding because there is no shunting effect. Taking factors such as these into account, product designers should develop basic designs for projection welding and not merely convert from a previous design. If this is done, cost will generally be lower and usually a better product results.

In designing for projection welding, careful consideration must be given to the type, shape and size of projections. Projections are embossed both hot and cold depending upon section thick-

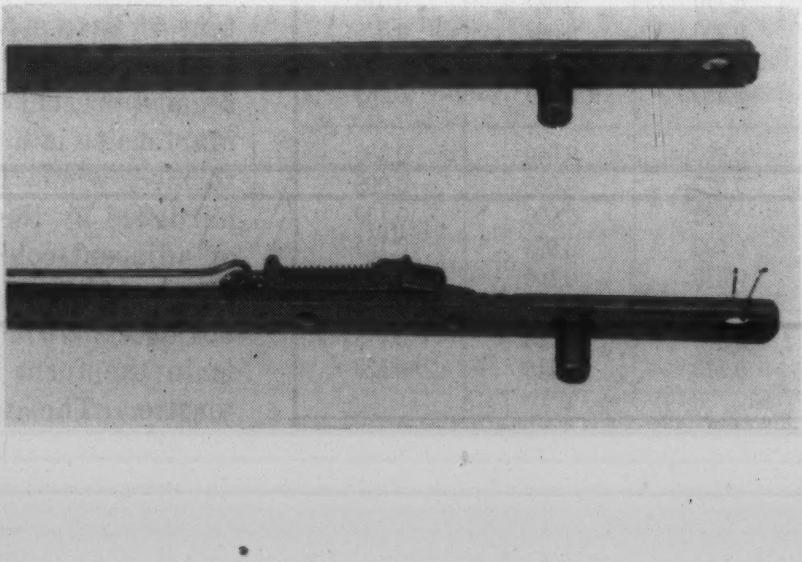


Part E—Ratchet, heavy spot welding (SAE 1045 to 1020); welded assemblies per hr, 200. Production ratio, 4.6 to 1.



Part F—Rig hanger, ten projection welds (SAE 1035, 1040, and 1045); welded assemblies per hr, 175. Production ratio, 7.6 to 1.

Part D—Lever, line projection weld (SAE 1035 to 1020 steels); welded assemblies per hr, 250. Production ratio, 5.5 to 1.



Facts About Projection Welding

1. Parts should be properly designed for projection welding.
2. Heavier sections than sheet steels can be welded.
3. Steel shapes of irregular geometry can be successfully welded.
4. One or several welds can be made at once.
5. Welds can be spaced closer with no shunting as compared to spot welding.
6. Welds of good strength are reproducible.
7. Using proper selection and location of projections, heat balance can be obtained between dissimilar sections.
8. To justify high capital outlay for welding equipment, jobs should be high production items—10,000 to 100,000 or more parts per year.

ness and type of steel. Fig 1 illustrates typical round and elongated projections embossed in plate.

In all projection welding, it is necessary to have point or line contact to start a weld. Button tips to flat plate is one example. Other steel parts, when located for welding, have natural projections due to their geometry as shown in Fig. 2.

In welding large rounds to plates, several projection designs have been used. In Fig. 3, the first three designs are located at positions of maximum stress. In the fourth design, the line projection welded joint, this condition is largely removed. Physical tests made on joints have demonstrated this design to be the best under static or dynamic loading conditions.

Fig. 4 shows a well planned line projection weld. Shaft end has a 30 deg chamfer, and the chamfer length is 75% of plate thickness. The plate hole is approximately 1/32 in. in dia larger than the shaft-end tip diameter. Holes can be drilled or punched. These welds are self-locating and elaborate fixtures in welding are not required.

Even in the best projection welds there is some flash present, and in production welding, as dies wear, some shaft marking is encountered. In the case of shaft bearings, shafts should be finished, turned or ground after welding. Shaft-plate joints, with line projection welds, have proved satisfactory in field service.

In the projection welding of sheet and plate steels, standards for projection sizes are available. The American Welding Society's "Recommended Practices for Resistance Welding" covers recommended projections for sheet and plate sections up to 0.25 in. Individual companies have developed their own standards up to 0.50 in. One such standard is given in the accompanying table.

BUICK STANDARDS FOR PROJECTION WELDING LOW CARBON STEEL

MATERIAL THICKNESS		PROJECTION DIA, IN.		PROJECTION HEIGHT, IN.	
Inches	U.S.S.G. (Approx)	Min	Max	Min	Max
0.012	30	0.075	0.080	0.015	0.020
0.014	29	0.075	0.080	0.015	0.020
0.015	28	0.075	0.080	0.015	0.020
0.016	27	0.075	0.080	0.015	0.020
0.018	26	0.090	0.095	0.020	0.025
0.021	25	0.090	0.095	0.020	0.025
0.024	24	0.090	0.095	0.020	0.025
0.027	23	0.105	0.110	0.025	0.030
0.030	22	0.105	0.110	0.025	0.030
0.033	21	0.105	0.110	0.025	0.030
0.036	20	0.120	0.125	0.030	0.035
0.042	19	0.120	0.125	0.030	0.035
0.048	18	0.135	0.140	0.035	0.040
0.054	17	0.135	0.140	0.035	0.040
0.060	16	0.150	0.160	0.040	0.045
0.067	15	0.150	0.160	0.040	0.045
0.076	14	0.170	0.185	0.045	0.050
0.090	13	0.170	0.185	0.045	0.050
0.105	12	0.200	0.215	0.050	0.055
0.120	11	0.220	0.235	0.050	0.055
0.135	10	0.230	0.250	0.052	0.060
0.150	9	0.250	0.270	0.052	0.060
0.165	8	0.270	0.290	0.057	0.065
0.180	7	0.290	0.310	0.057	0.065
0.195	6	0.310	0.330	0.062	0.070
0.210	5	0.330	0.350	0.062	0.070
0.225	4	0.350	0.370	0.067	0.075
0.245	3	0.370	0.390	0.067	0.075
0.265	2	0.390	0.410	0.072	0.080
0.281	1	0.410	0.430	0.077	0.085
0.312	0	0.450	0.480	0.080	0.090
0.343	2.0	0.490	0.520	0.085	0.095
0.375	3.0	0.530	0.560	0.090	0.100
0.406	4.0	0.560	0.590	0.095	0.105
0.437	5.0	0.600	0.630	0.100	0.110
0.468	6.0	0.640	0.670	0.105	0.115
0.500	7.0	0.680	0.710	0.110	0.120

As sections increase in thickness, the diameter and height of projections are increased to develop required strength. On dissimilar sections, the projection is generally placed on the heavier part.

Steels for projection welding

Low carbon steels (0.30% max carbon) are commonly used in resistance welding and such steels have good weldability. However, if resistance welding were confined to low carbon steels only, its use would certainly be limited in our field—the fabrication of farm equipment parts. As the carbon of the steel increases above 0.30%, the hardenability of steel increases and easy weldability decreases. Therefore, special procedures have to be used in welding medium or higher carbon steels.

In welding of hardenable steels, martensite and high hardness occur in the weld heat-affected zone. The higher the carbon content of base steel, the greater the percentage of high carbon martensite present and the hardness. Martensite is a brittle constituent formed when the base steel is hardened by the quenching action of adjacent cold metal.

It is desirable that martensite not exceed 10% and, if present, it is in the form of tempered martensite. The weld heat-affected

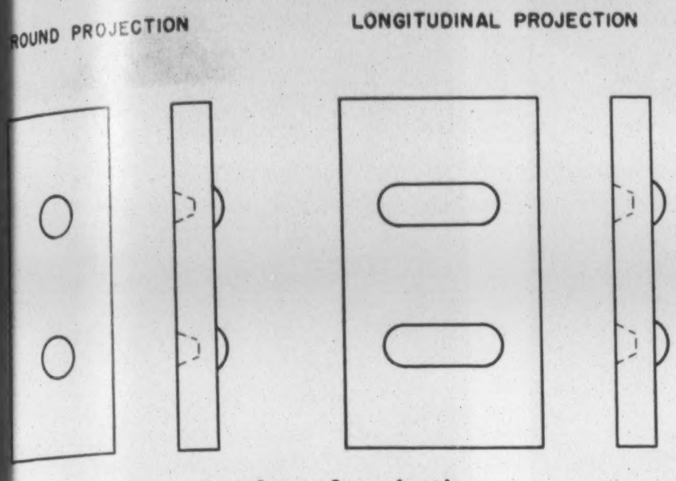


Fig. 1—Button or embossed projections.

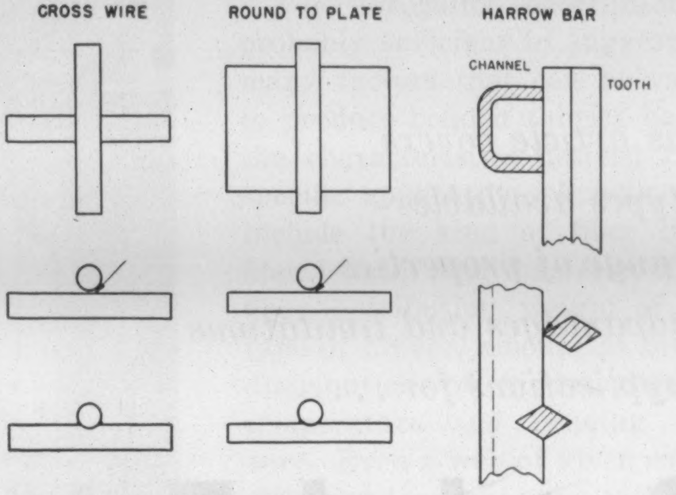


Fig. 2—Natural projections.

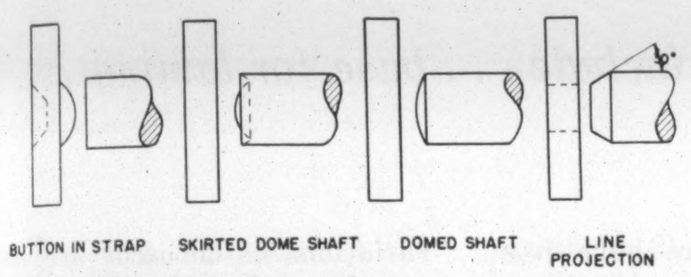
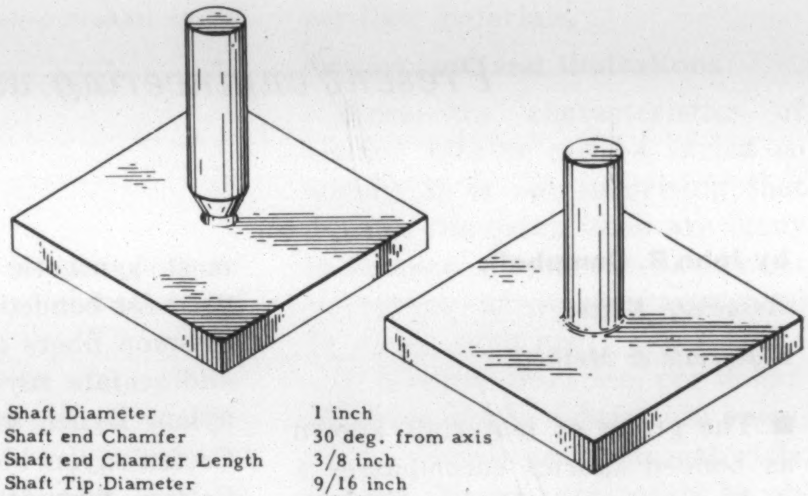


Fig. 3—Rounds to plate series.



Shaft Diameter	1 inch
Shaft end Chamfer	30 deg. from axis
Shaft end Chamfer Length	3/8 inch
Shaft Tip Diameter	9/16 inch
Plate Thickness	1/2 inch
Plate Hole Diameter	5/8 inch

Fig. 4—Design of line projection weld.

zones to be preferred would have no martensite and a hardness not over R_c 30. High hardness and martensite in heat-affected zones can be avoided by using impulse welding or high heat input post-heat and thus prevent the critical base steel cooling rate that forms martensite.

Under controlled conditions, 1035, 1045, 1055 and 1070 steels have been successfully projection welded. Some of these jobs are: 1) 1018 steel studs to 1045 steel in combine rasp bars, 2) 1045 to 1045 steel in harrow bars and 3) 1070 to 1070 steel in planter check forks. The resistance welding of rerolled rail steels is not recommended. It is possible to resistance weld some types of resulfurized steels.

Scale-free clean surfaced steel should be used in production projection welding. Cleaning costs are not high and clean steel offers three important advantages: 1) uniform heat input to parts, 2) lower copper die maintenance cost and 3) uniform welded joint strength. Scaly surfaces cause resistance variation between parts which affects current flow and weld strength.

This article was adapted from a paper presented at the National Fall Meeting of the American Welding Society.

Planning for Projection Welding

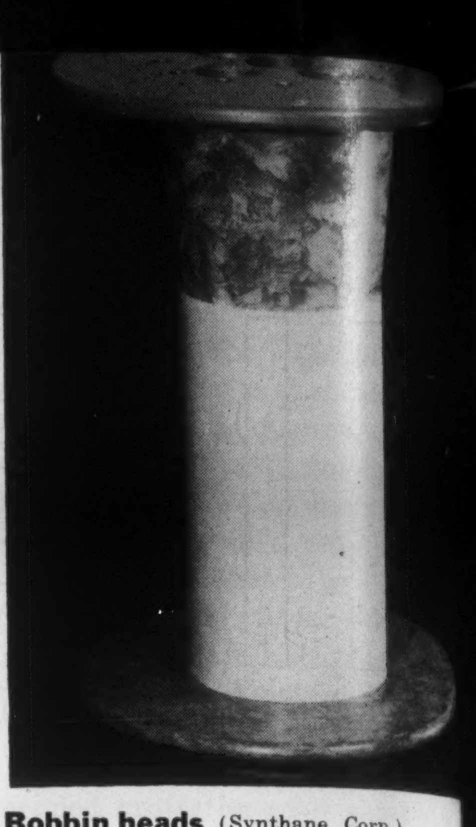
Development of parts for projection welding was a joint effort of factory product designers, methods men and the welding laboratory. Based upon our experience, any program to make the best use of the heavy projection welding process should begin with a survey of parts suitable for this process. Sample weldments can be made and field tested. This can apply to both light and heavy section parts. The plan assumes, of course, that experimental welding equipment is available.

In making sample weldments, costs can be accurately estimated for the actual welding time. Assuming good production fixturing and simulated motion study, fairly accurate floor-to-floor time can be determined and weld production per hour conservatively estimated using proper delay factors. Our experience has shown that actual production of welds per hour normally exceeds early estimates. The engineer, therefore, should not be too conservative in selecting an adequate rated kva welder for the job.

This article covers

- *types available*
- *range of properties*
- *advantages and limitations*
- *applications for . . .*

Bonded Fabrics



Bobbin heads (Synthane Corp.)

Present engineering uses include . . . base for laminates . . .

by John B. Campbell,
Associate Editor,
Materials & Methods

■ The group of materials known as bonded fabrics encompasses a wide range of physical and chemical characteristics. Some bonded fabrics are suitable only for padding, whereas others are capable of withstanding severe service conditions. In general, there are no industry-wide materials specifications for bonded fabrics. Although a number of more or less standard fabrics have been developed by different manufacturers to serve present industrial uses, the chances are that the optimum fabric for a new use would be one developed specifically for that purpose. For the most part, therefore, this article will describe not individual fabrics, but rather the many variables that can be adjusted to provide a fabric having the desired combination of properties.

Types of fabrics

A bonded fabric has two principal components: a web of textile fibers plus a binder. The nature of the web, the nature of the binder and the relative amounts of web and binder may vary over a broad range.

Virtually all natural fibers and most synthetic fibers have been used for bonded fabrics. The most common fibers are cotton, viscose and acetate rayons, wool, Dacron, nylon, Dynel, glass and asbestos. Cotton-rayon blends are common. Cotton provides fabrics having maximum softness and drape, whereas rayon increases stiffness and shaping ability. Synthetic and inorganic fibers are used principally where special properties such as high strength, heat resistance or chemical resistance are desired. Since no spinning is required, reprocessed wool, cotton thread waste and similar low-grade fibers can also be used.

Bonded fabrics are made with either a carded or a random web. A carded web—the most common type—is essentially parallel in structure; it has maximum strength in the longitudinal or "machine" direction and considerably lower strength in the transverse or "cross" direction. Several carded webs may be superimposed to form a thicker composite web. A "cross-oriented" web that has equal strength in the machine and cross directions can be made by continuously laying down on the first web another parallel web at a right angle.

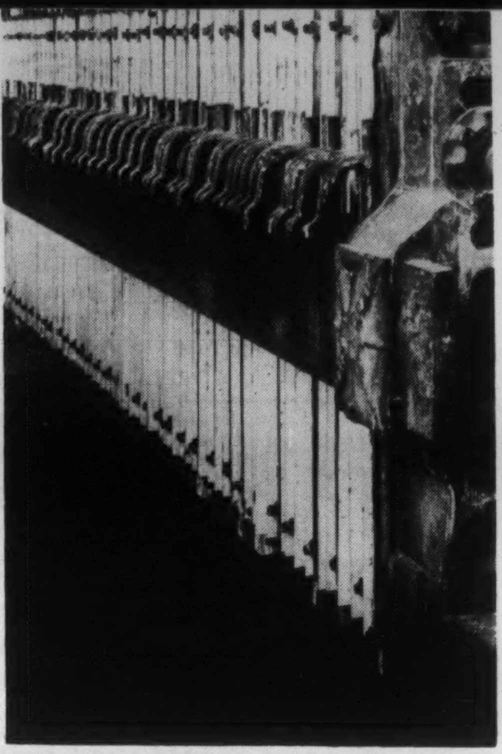
A random web is nominally one in which fibers are uniformly distributed in all directions and such variations as do occur are essentially random in character. It has uniform density and approximately equal strength in all directions within the plane of the web. A fairly random web can be formed by a process which employs air streams to mix fibers and fiber clumps and blow them onto a collecting screen, the resulting web then being consolidated by calendering. This process is most suitable for medium to heavy webs. It is not as suitable as carding for long fibers; therefore web strength is more limited. As yet blown webs do not appear to be as uniform in density as many carded webs.

There are two general methods of bonding a web. One method is to introduce an adhesive substance by dipping, printing or spraying it on the web, then complete the bonding by drying, curing or fusing the adhesive substance. The other method—developed by Kendall Mills, Inc.—is to incorporate thermoplastic fibers in the web originally, then complete the bonding by fusing the thermoplastic fibers to the other fibers in the web. Both methods usually employ some bonding pressure (by calendering or other means) to improve adhesion and to establish the desired thickness and density.

Fabrics bonded by dipping—the

Auto upholstery (Ford Motor Co.)

backing for vinyl



Chemical filters

(Brosites Products Corp.)

. . . sheet filter media

most common technique—utilize many different binders, some of them thermosetting. Acrylonitrile rubber, polyvinyl acetate and viscose are the binders most widely used today.

A softer fabric with more "drape" can be produced by "discontinuous" impregnation, where printing techniques are used to apply binder to a carded web according to a definite predetermined pattern. Bonding points are usually spaced at about one-half the fiber length. Such a web is usually less than 50% bonded and is consequently not nearly as strong as a dipped web. Impregnation patterns are often designed with a view toward improving transverse properties. Diamonds, dots and transverse bars are among the most common patterns and a doughnut pattern has recently been introduced.

Bonding by spraying and fusing a thermoplastic powder on the web is not widespread because of the difficulty in obtaining satisfactory uniformity. However, The Felters Co. uses this method to produce felt-like fabrics ("All-Fab") from a variety of original and reprocessed fibers.

Fabrics bonded with thermoplastic fibers are inherently more expensive than impregnated fabrics because of the cost of the synthetic fibers, but they have an unusually good combination of strength and porosity. The binder content may also be varied throughout the depth of a composite web where a non-uniform fabric is desired. The bonding fibers most widely used are plasticized cellulose acetate, Vinyon and Dynel. Because significant pressure is required for good bonding, fiber-bonded fabrics are not very economical where relatively thick, low-density structures are desired.

The foregoing description is probably sufficient to suggest the many factors that can be varied to produce bonded fabrics having the characteristics desired for a specific application. Briefly, they include the kind of fiber itself, fiber length, fiber diameter, crimp, fiber distribution, weight of web, type of binder, amount of binder, distribution of binder, bonding temperature and bonding pressure. Even a web of given composition and weight may yield fabrics ranging from fluffy, felt-like materials to thin, semi-rigid, paper-like materials.

Advantages and limitations

Since the characteristics of bonded fabrics can be varied so widely, it is not surprising that reasons for using them are many in number. In general, their most important advantages compared to woven cloth are:

1. Greater thickness per dollar. Whereas woven fabrics are essentially two-dimensional materials, bonded fabrics can readily be obtained as lightweight or compact three-dimensional structures.

2. Lighter weight (or less thickness) per dollar. Whereas fine yarns cost more per pound than coarse yarns, the cost per pound of bonded fabrics does not

What is a "Bonded Fabric"?

A bonded fabric, according to ASTM D-1117, is "a structure consisting of a web or mat of fibers held together with a bonding material". The nature of the bonding material is made more explicit by ASTM D-123 which defines it as "a cementing medium which does not form a continuous sheet of adhesive material".

The terms "bonded fabric" and "non-woven fabric" are often used interchangeably. Although the latter term distinguishes bonded fabrics from woven cloth, it does not distinguish them from other non-woven fabrics, such as paper, felt and felt-like materials, which do not incorporate any binder. Among the relatively new non-woven fabrics which are *not* bonded fabrics are a chemically "felted" cotton mat, nylon paper, and synthetic organic "felts" such as Dacron which employ the needled-batt construction. This article covers only those non-woven materials which are properly called bonded fabrics.

Much of the current interest in bonded fabrics is centered on attempts to develop satisfactory outerwear materials for the garment industry. Of the two dozen or so manufacturers, however, a few have devoted considerable effort to developing materials specifically for industrial applications.

increase as they become thinner.

3. A less expensive smooth surface. Whereas a smooth woven fabric requires the more expensive fine yarns and a close weave, a smooth bonded fabric can be obtained simply by adjusting such variables as fiber diameter, binder content and bonding pressure.

4. Lower cost. Although the cost per pound of many bonded fabrics now available may be no less than the cost of comparable woven fabrics, bonded fabrics composed of waste or reprocessed fibers will certainly cost less than woven fabrics.

Other advantages, such as stiffness, isotropic properties and greater effective porosity are discussed below.

Chief limitations of bonded fabrics compared to woven cloth are lower abrasion resistance and lower strength-weight ratio per dollar.

Applications

Bonded fabrics have had considerable impact in consumer textile applications such as dish towels, millinery and disposable diapers. Of the numerous engineering uses that have been developed, probably the most important at the present time are: a base for a cold-punching thermosetting laminate; a backing for vinyl film; and chemical filter media. These and other engineering uses are described briefly below.

Base for laminate—Bonded fabrics have been used as a base for thermosetting plastic laminates for a number of years. Such fabrics contain only enough binder to hold them together during impregnation and laminating. The random glass mat used in most low pressure polyester laminates, as well as the Pyrotex asbestos felts described elsewhere in this issue (p. 103), can properly be classified as bonded fabrics. Probably the most important use of bonded organic fabrics for laminates is in textile machinery parts made from high pressure phenolic laminates.

TABLE 1—PROPERTIES OF BONDED FABRIC LAMINATES [a]

Property \ Material	Laminate from Random Bonded Fabric	ASTM and NEMA Specifications		Commercial Laminates Made from Woven Cotton Fabrics[b]	
		Grade L	Grade C	Average	Range
Tensile Strength, psi	16,900	7000	7500	9600	8300-12,000
Flexural Strength, psi	21,850	15,000	16,000	18,400	15,600-21,900
Izod Impact, ft lb/in. of notch					
Machine Direction:					
Face	6.2	—	—	4.5	3.5-6.3
Edge	2.7	—	—	2.5	2.1-2.5
Cross Direction:					
Face	7.5	2.5	3.2	4.3	3.4-6.8
Edge	2.6	1.2	2.0	2.4	1.9-2.4

[a] *Adapted from* Haven.

[b] *Data from R. K. Witt, P. D. Wolfe, and D. M. Rust, "Cotton Fabric Laminates"*, Modern Plastics, *v.25, 1948.*

A number of unique properties can be obtained in laminates made with random bonded fabrics. They include: exceptionally good machinability at high cutting speeds; a mirror-like machined surface that tends to be self-healing when abraded; equal strength in all directions within the plane of the laminate; and better impact strength and resistance to repeated impact than conventional grades, such as paper-canvas. A comparison of impact data is given in Table 1. The following data, cited by Wellington Sears, further indicate the nature of the difference in directional strength and impact fatigue between conventional and bonded fabric laminates:

Direction of Blow	Number of Repeated Blows Withstood	
	L grade	Lantuck
Lengthwise	38	42
Crosswise	36	44
Diagonal	2	44

One part that has been particularly successful is a bobbin head, where a smooth surface is of great importance. A typical material for this application is a random cotton fabric bonded with a minute amount of polyvinyl acetate and weighing about 3 oz per sq yd. A similar fabric is used in vibrator blocks for textile looms; these blocks have lasted about 50 times as long as the wooden blocks previously used. Because of their toughness, bonded fabric laminates are also recommended for parts having thin projections, such as small gears.

Backing for vinyl—Bonded fabrics are now used extensively as a backing material for vinyl film in automobile door panels, scuff pads and seat upholstery. A fabric backing makes handling easier, increases the tear resistance and stitch strength of vinyl film, and also absorbs shock, thereby tending to reduce cold cracking. A bonded fabric provides maximum thickness at minimum weight and cost. Its good finish permits a smooth vinyl surface; on the other hand, its deformability allows it to maintain a grained or other embossed design in the vinyl surface.

A typical calendered or laminated material for door panels consists of 0.018-in. random cotton fabric and 0.012-in. vinyl sheet; the cotton fabric weighs about 2¾ oz per sq yd and is continuously bonded with about one-third by weight of a vinyl resin. A quilted effect may be obtained by interposing a fluffy, inexpensive, thermoplastic-bonded fabric between the backing and the vinyl film. The quilt is made by simultaneously heat sealing together the viny film, the padding and the backing.

Unlike door panels, seat coverings require a material that can be stretched readily in all directions. Wellington Sears has reently introduced a new bonded fabric which it believes can compete with knit fabrics as a backing for vinyl seat upholstery. Called Lantuck N-R, the fabric is a random blend of nylon and rayon, mostly nylon, bonded with a specially-developed thermosetting resin. This fabric, ranging from 0.018 to 0.038 in. thick, is heat sealed to the vinyl sheet. Compared to vinyls backed by knit fabrics, the new composite is claimed to have equal stitch strength, better tear resistance and lower permanent set. Stretch and recovery characteristics are claimed to be "outstanding".

Filter media—Bonded fabrics used for filtering are usually bonded by thermoplastic fibers. (An important exception is milk filtration which requires a very fine pore size and utilizes a fabric bonded by impregnation.) One major use of fiber-bonded fabrics is a disk-shaped vacuum cleaner filter. A typical fabric for this application consists of an 80:20 blend of cotton and cellulose acetate fibers, weighs about 8 oz per sq yd, is about ¼ in. thick, and has a density of 4.5% of specific gravity and an air permeability of 300 cfm per sq ft (0.5 in. H_2O). A technique developed a number of years ago by American Felt Co. allows a fluffy, lightweight filter and a semi-rigid flange to be made in one piece; it consists of bonding the carded web by means of a heated die shaped in such a way that pressure is applied around the edges of the filter and little or no pressure is applied to the main portion of the filter.

In recent years dense bonded fabrics made entirely of synthetic fibers have been adopted for a number of filtration operations in chemical and pharmaceutical plants. Such fabrics have better stiffness and retain smaller particles than many tightly woven cloths of the same weight. Yet their effective porosity and, consequently, their flow rates are much higher. Bonded fabrics are also claimed to clog less and to reduce leaking in plate and frame filters. They can be cut without producing frayed ends or causing unraveling, and they can be supplied with an "egg-shell" finish that makes cake removal easier.

Data for typical filter media of Dynel, Dacron and nylon made by American Felt are given in Table 2. Similar fabrics of lower density and higher flow rates are also available. Although Vinyon binder fiber is widey used for chemical application, attempts are being made to develop new chemical-resistant, thermoplastic fibers, such as plasticized nylon or Dacron, that have higher softening points and would therefore permit higher operating temperatures.

Although fiber-bonded fabrics have been used chiefly on plate frame presses so far, they show promise for virtually all types of filters that use sheet-like media. A competely nonmetallic pressure leaf filter was made recently by combining a bonded fabric with a plastic screen. Bonded fabrics are also being tested for rotory vacuum filters.

Because of the greater stiffness and filtering efficiency of bonded fabrics, a fabric weighing only 10 oz per sq yd has been found satisfactory for most chemical filtering jobs. Reduction in weight of material and lower maintenance cost have made bonded fabrics more economical than woven filter media for many applications. Replacement of woven fabrics by bonded fabrics has resulted in materials savings of up to 40% or more in some plants.

Others—Various types of bonded fabrics are being used or considered for spacers, seals, gaskets, bumpers, wicking, acoustical tile, dessicant bags, battery separators, friction tape, lamp base pads, permanent wave pads, wallboard tape and vacuum cleaner bags. They may also prove useful in cable wraps as a carrier for a dielectric film such as nylon.

Acknowledgment

The author appreciates the help given by Hugo Boeddinghaus of American Felt Co., D. V. Probasco of Wellington Sears Co. ("Lantuck"), John C. MacIlroy of Chicopee Mills, Inc. ("Masslin"), John Trickey, Jr., of Kendall Mills, Inc. ("Webril"), and H. L. Leventhal of The Visking Corp. ("Viscon").

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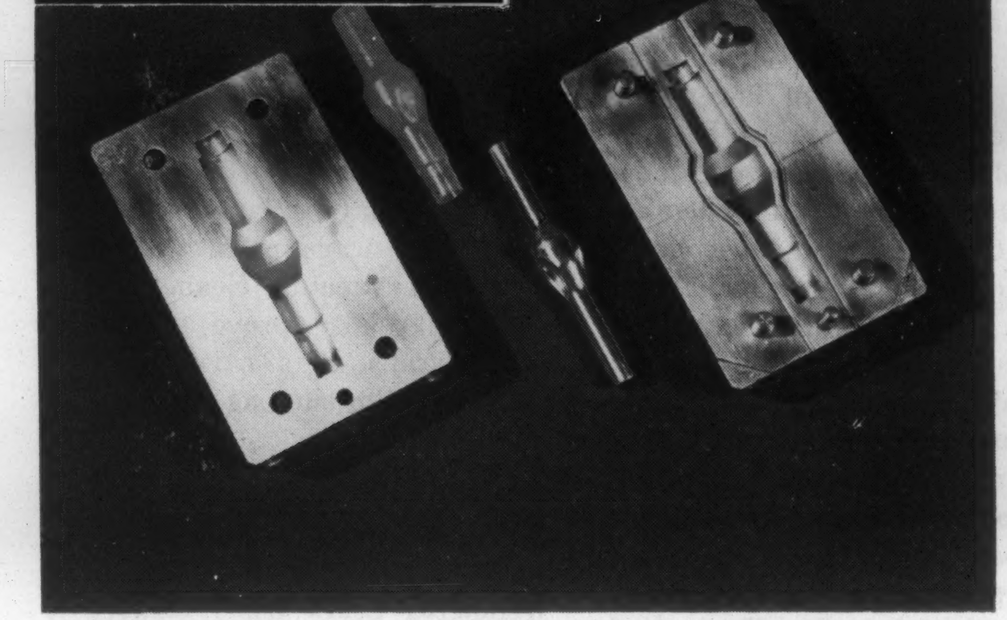
TABLE 2—PROPERTIES OF BONDED FABRICS FOR FILTRATION [a]

Fabric / Properties	Dynel (3 denier) Type I	Nylon (1.5 denier) Type I	Dacron (3 denier) Type I
Weight, oz/sq yd	10	10	10
Thickness, in.	0.025	0.030	0.026
Density, % specific gravity	53	45	51
Tensile Strength, psi	2400	5000	5000
Breaking Strength, lb/2-in. width	120	335	243
Mullens Bursting Strength, psi	230	390	350
Elongation at Rupture, %	75	77	52
Porosity	46	58	43
Air Permeability (clean), cfm/sq ft/0.5 in H_2O	1-3	1-3	1-3
Water Permeability (clean), gpm/sq ft/1.0 psi	4-14	4-14	4-14
Principal Use	General purpose filter media	Filter media for alkaline solutions	Filter media for acid solutions

[a] *Bonded with Vinyon fiber. All of these fabrics can be used at temperatures from —20 to 150 F and have zero shrinkage at 150 F.*



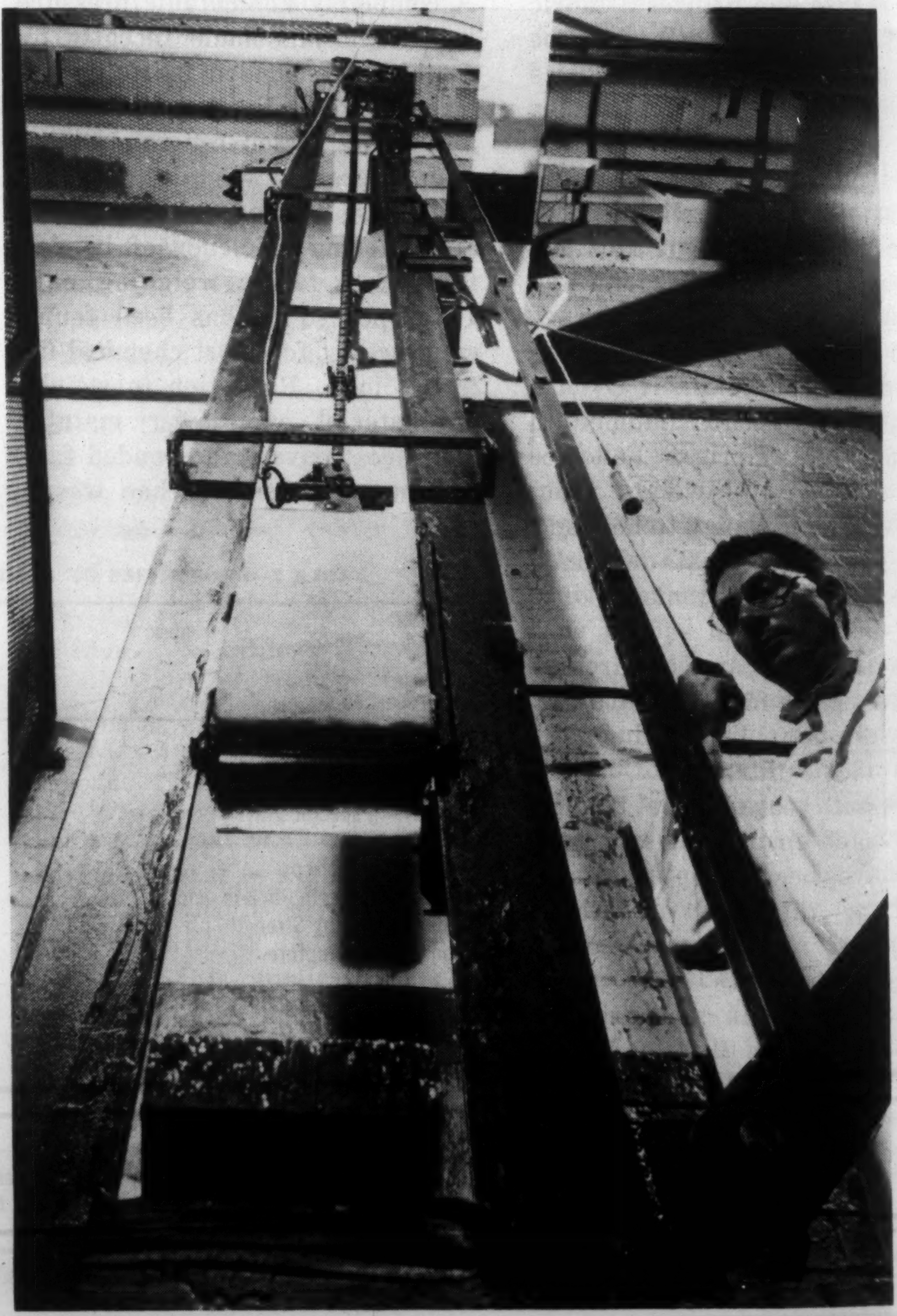
Silicone rubber heart valve

Physiological inertness and permanent resilience of silicone rubber have made it a promising material for a substitute valve proposed for use in the human heart. Shown here with a stainless steel mandrel and the two-part mold, the valve is a simple ball-check unit consisting of a molded Silastic case and an acrylic ball. Silicone rubber replaced the earlier-used acrylic when it was found that the harder acrylic caused damage to red blood cells and also caused an annoying ticking during operation.

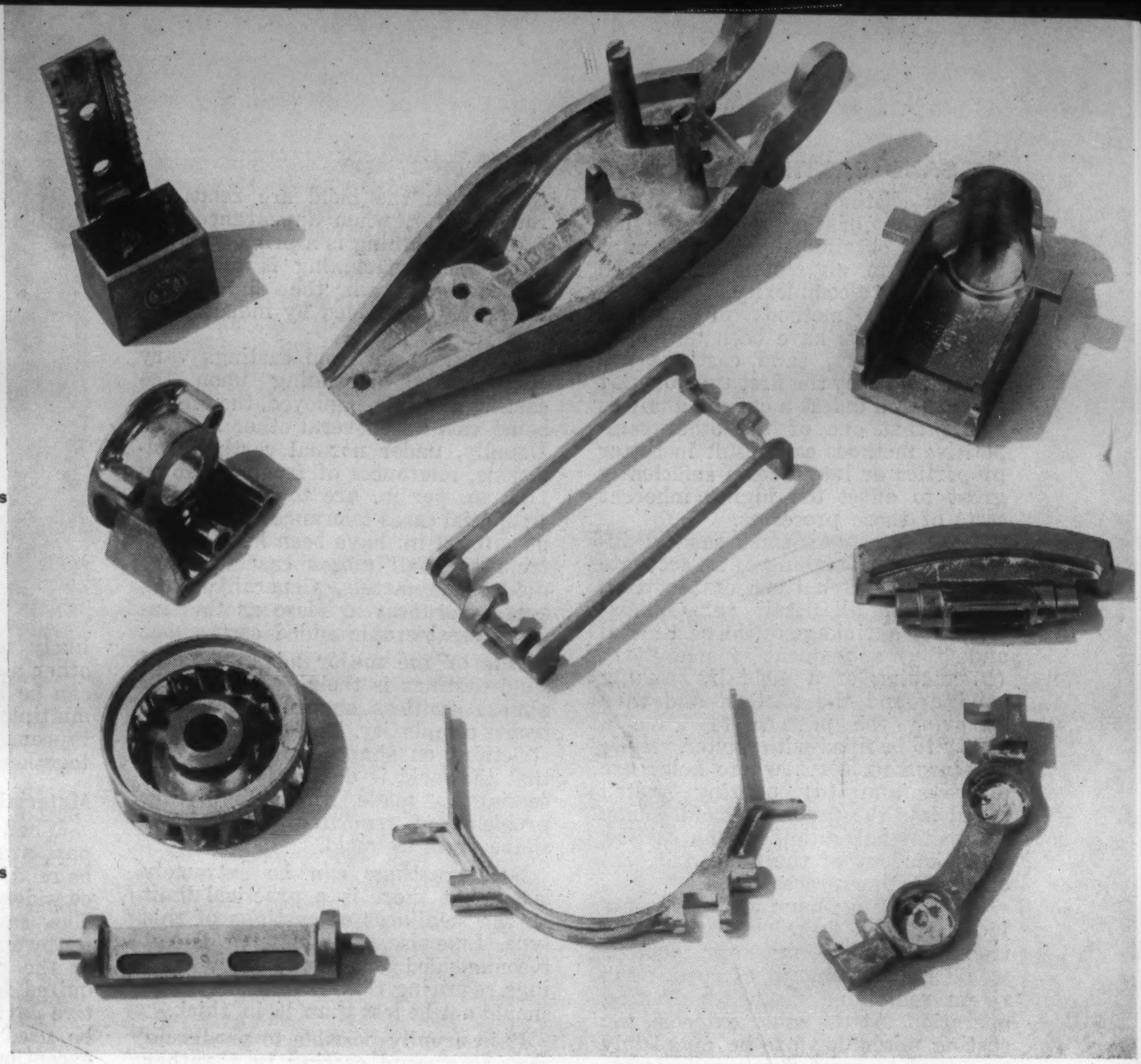
The valve is designed to by-pass crippled aortic valves and relieve aortic stenosis. It was developed by a group under Dr. Stanley J. Sarnoff of the National Heart Institute and molded by Dow Corning Corp.

Guillotine tests shock resistance of metals

An impact guillotine is being used effectively by Westinghouse Electric Corp. to determine the transition point between ductile and brittle zones of metals. Though the Charpy Impact Test has long been used for this purpose, sample preparation takes considerable time and care. The impact guillotine uses a larger sample, 14 in. long, 3½ in. wide and 1 in. thick. Instead of the notch, a weld bead is put on the bottom of the sample and an artificial crack is made in the weld by a cutting wheel. A standard weight is dropped on samples at various temperatures, and the transition temperature can be readily bracketed within a narrow range. Results are reproducible and sample preparation time has been cut to 1/3 that of the Charpy method.



Sand Castings
Shell Mold Castings
Permanent Mold Castings
Plaster Mold Castings
Investment Castings
Die Castings
Drop Forgings
Press Forgings
Upset Forgings
Cold Headed Parts
Extruded Shapes
Impact Extruded Parts
Roll Formed Shapes
Stampings and
Press Formed Parts
Powder Metallurgy Parts
Spinnings
Screw Machine Parts
Electroformed Parts
Sectioned Tubing
Welded, Brazed and
Bonded Assemblies



Fabricated Metal Parts—Design and Selection Factors

A Staff Report

MATERIALS & METHODS MANUAL NO. 124

This manual replaces Manual No. 54 (December 1950) on the same subject. It is another in a series of comprehensive articles providing useful information on characteristics and uses of materials, parts and finishes.

FEBRUARY 1956

This manual consists of two essential parts which are intended to be used together. First will be found summaries of the essential features of the twenty types of metal parts most used in product design and manufacture. The second important feature consists of four pages of comparative data in tabular form. By using the two sections it will be possible to determine with reasonable accuracy the most suitable part for any application under consideration.

■ *Descriptions of Parts.........p 122*
■ *Design Features.............p 132*
■ *Cost Features...............p 134*
■ *Forms and Materials Table....p 138*

1. SAND CASTINGS

Sand castings, from the earliest days of civilization, have been the means of obtaining metal shapes of all sizes, in all metals and to all degrees of complexity. Although many other methods of forming metal products have been developed over the years, sand castings are most frequently the first type of part investigated unless a careful analysis shows that one of the other competitive methods can result in better properties or lower costs sufficiently great to offset the higher inherent costs of those processes.

The process of sand casting involves (a) the making of an accurate wood or metal pattern of the part, accurate in all detail (plus allowances for shrinkage of the cast metal and for subsequent machining); (b) making of a mold by packing sand around the pattern and then removing the pattern to leave a cavity to be filled with molten metal; (c) inserting cores where holes are desired; and (d) pouring molten metal into the prepared mold. When the metal has solidified, the casting is shaken out of the mold and sent on for further processing.

Sand castings must always be subjected to some finishing work. In extreme cases the only work required would be the removal of sprues and risers remaining from the casting operation. At the other extreme, the casting might have to be completely machined to meet finish and dimensional tolerance requirements.

Design features

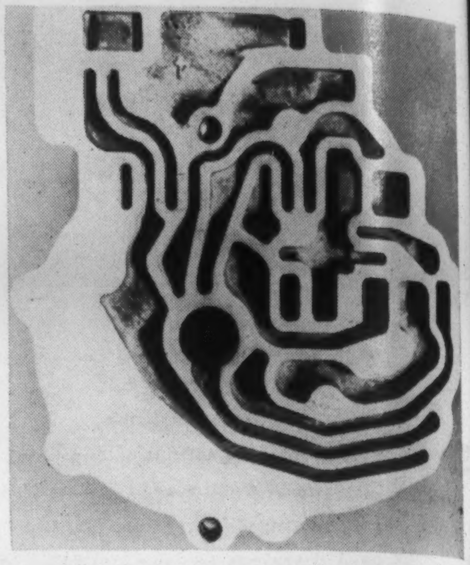
Generally, sand castings as they come from the mold are relatively rough. Thus, when appearance is a factor, machining is a prime requirement. Too, machining is often required to obtain the dimensional tolerances demanded by industry today.

Tolerances on sand castings vary considerably, depending upon the casting methods employed, the metals being cast and several other factors. Usually, under normal casting conditions, tolerances of from ±1/16 to 1/32 in. per in. are to be expected. In special cases tolerances of as little as ±0.003 in. have been held on extremely small pieces cast in some nonferrous metals. Generally, however, tolerances as close as this involve considerable added cost.

One of the major advantages of sand castings is their availability in almost limitless shapes and of extreme complexity. There are few restrictions on shape due to the fact that the mold is destroyed after the casting is made, thus eliminating problems of removing the finished shape from its mold.

Sand castings can be extremely large, but there is a practical limit on the smallness of castings of this type. Likewise, sand casting is not recommended for the making of castings requiring thin sections. Sections should not be less than ⅛ in. thick.

It is usually possible to produce a part as a sand casting in a rather short period of time because no complicated tools or dies are required. On the other hand, with moderate sized pieces the rate of output is likely to be lower than for many other methods of production. Output can be increased, however, by using multiple cavity molds or by simultaneously pouring several molds held together in one flask.



Materials

When moderate quantities of a part are required, sand castings can be relatively inexpensive even though considerable hand labor is required. The savings are achieved because pattern costs are low as compared to the costs of dies and molds required for the production of competitive parts. Practically any metal can be used in sand castings with the exception of the newer metals which react with air while in the molten state. For precision parts, sand casting are usually restricted to the light alloys and certain bronzes.

2. SHELL MOLD CASTINGS

Newest of the casting methods, shell molding, produces parts having a high degree of dimensional accuracy and a finish of sufficiently high quality to eliminate the need for most finishing operations. In many respects, shell molding compares with sand casting, but with the exception that the mold in which the casting is poured is composed of a mixture of sand and resin which has been formed over a metal pattern and then baked. Shells can be made with extremely smooth surfaces, sharp corners and fine detail. The shell, in turn, imparts these qualities to the finished casting.

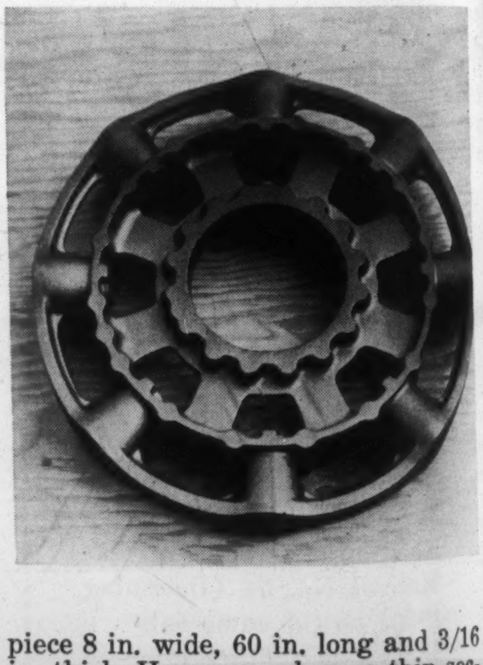
Most metals are said to be superior in quality when used as shell mold castings and compared to the same alloys converted into sand castings. The increase in quality is believed to be largely due to the porosity of the shells which permit gases to escape and also because the shells are dry and do not release moisture when they come into contact with hot metal.

Design features

Many claims have been made for shell mold castings, based on laboratory results, some of which cannot be substantiated under production conditions. Most extravagant claims have been made as to dimensional tolerances attainable. Even when enthusiasm is tempered a little, the possibilities are still excellent. In production, it is common to achieve tolerances of ±0.003 to 0.005 in. per in. of casting in dimension within one-half of the shell. Some foundries have been able to hold to dimensions even more closely on larger pieces. When the dimensions fall across the parting line of the mold, they should be doubled.

Present mold making machines limit the sizes in which shell mold castings can be produced. The largest machines are capable of making molds up to 60 in. square. General opinion indicates that the largest castings should be between 20 and 30 lb. As sizes increase and tolerances decrease, costs rise appreciably, thus making the process less attractive for parts having those requirements.

Shell molding permits the casting of small plane areas, some down to a thinness of 1/16 in. Some long, thin sections have been successfully cast, as for example an alloy steel piece 8 in. wide, 60 in. long and 3/16 in. thick. However, where a thin section joins a thicker section, it is desirable to provide a gradual transition. The only need for draft allowances in shell mold castings is to permit the shell to be removed from the pattern. Usually 1/2-deg draft is sufficient.



As with any metal part, sharp angles should be avoided unless absolutely necessary in shell mold castings, although the process is capable of reproducing such angles when necessary. Limitations are imposed by the metals being cast, rather than by the process itself.

Excellent surface finish is one of the strong points of shell mold castings. Under ordinary conditions surface finishes of 60 rms can be attained, depending upon the size of the casting and the metal being cast. Fine sands can be used in the shells for small castings, thus permitting better surfaces on the small castings.

Materials

The range of materials which can be cast in shell molds is quite wide, almost equaling the versatility of sand casting. There are a few metals and alloys which cause difficulties. For example, the low carbon steels are prone to various surface defects although new techniques are hopeful of overcoming this problem. Brasses and bronzes with high lead and tin contents are inclined to sweat and cause trouble. The reactivity of magnesium with oxygen and silica sand requires the use of special inhibitors in the shell to avoid casting difficulties.

3. PERMANENT MOLD CASTINGS

Permanent mold castings, sometimes known as gravity castings, are, as the name implies, made in molds that are designed for repetitive use. Molds are made in two or more parts and are hinged and clamped for easy removal of the finished castings. Parts made as permanent mold castings must be of relatively simple design although some degree of complexity can be attained by the use of sand core in conjunction with the iron or steel molds. When sand cores are used, the process is known as semi-permanent molding.

Parts made as permanent mold castings have good mechanical properties, due largely to the chilling effect of the metal molds. Quality can be controlled by heating the molds prior to pouring and by the use of plaster mold materials in certain areas to achieve different cooling rates. Permanent molds are used to produce slush castings, which are made by emptying the mold of liquid metal after a shell has been formed by the solidification of metal immediately adjacent to the mold surfaces.

Permanent mold castings are usually dense and fine-grained and can be made with better surfaces and closer tolerances than sand castings. Tolerances must be wider than for die castings, shell mold castings and plaster mold castings. Tool costs are lower than for die castings, higher than for sand, plaster and shell mold castings. Permanent mold castings offer good possibilities where moderation, but not the ultimate in complexity, dimensional tolerances or high speed production are desired.

Design features

Dimensional tolerances of permanent mold castings can usually be assumed to be within the range of ±0.025 in. on average sized pieces. Closer tolerances can be held when the occasion demands, but the original tolerances provided by the molds are likely to grow larger in time due to wear on the mold. Required draft angles of 2 to 3 deg to permit removal of pieces from the molds add to drawing dimensions on some parts. Tolerances are affected by ceramic mold washes which are used to prevent mold damage and assist in casting removal.

The average size of permanent mold castings varies from about ½ lb up to about 12 lb although there is now a trend toward larger and heavier castings of this type. As to size, the majority of castings have a minimum size of 2 in. dia by ½ in. thick up to 10 in. dia and 1 in. thick.

Materials

Materials which can be used in permanent mold casting form are generally limited to a relatively few low melting point alloys. Some gray iron castings are made by this method with considerable success; the high pouring temperatures are likely to damage the mold materials and reduce service life considerably. Copper-base alloys are also cast in permanent molds, but here too the pouring temperatures required are such as to be harmful to the molds. Thus, the majority of permanent mold castings are made of aluminum and magnesium alloys. When the process is used to make slush castings, the materials most frequently used are zinc and lead alloys.

4. PLASTER MOLD CASTINGS

Plaster mold castings are noted for their fine finishes which, of course, reflect the smoothness of the plaster in which they are cast. To obtain the mold, a slurry of gypsum is poured around an accurate model of the part to be made. When the plaster has set, it is then baked to enable it to withstand the pressures of molten metal. Some completed molds are assembled from many smaller components. The mold is then broken after casting solidification for the removal of the finished parts.

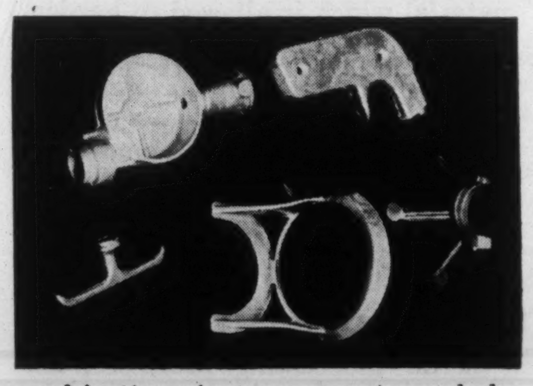
Although plaster mold castings are used on some high production parts, they are usually considered for small to medium sized lots. Molding costs are relatively high, but these costs are usually recovered because of the minimum of machining required to make the castings usable.

Certain properties of metals cast in plaster molds are somewhat inferior to those attainable through competitive processes, although the properties are usually more uniform throughout the piece. The insulating quality of the plaster mold tends to develop a slow cooling rate in plaster mold castings and promote coarse grain structures in the metal. The result is some reduction in tensile and elongation properties.

Design features

The finish on plaster mold castings is generally in the range of 50 to 60 rms and surface detail can be produced faithfully. Surface quality is somewhat less with certain alloys, and in these instances parts made by some of the other quality processes would be superior.

As to tolerances, plaster mold castings have much to offer. Some foundries promise ±0.005 in. per in. of casting, while others promise even better, feeling that the ±0.005 in. applies only to the first inch and that



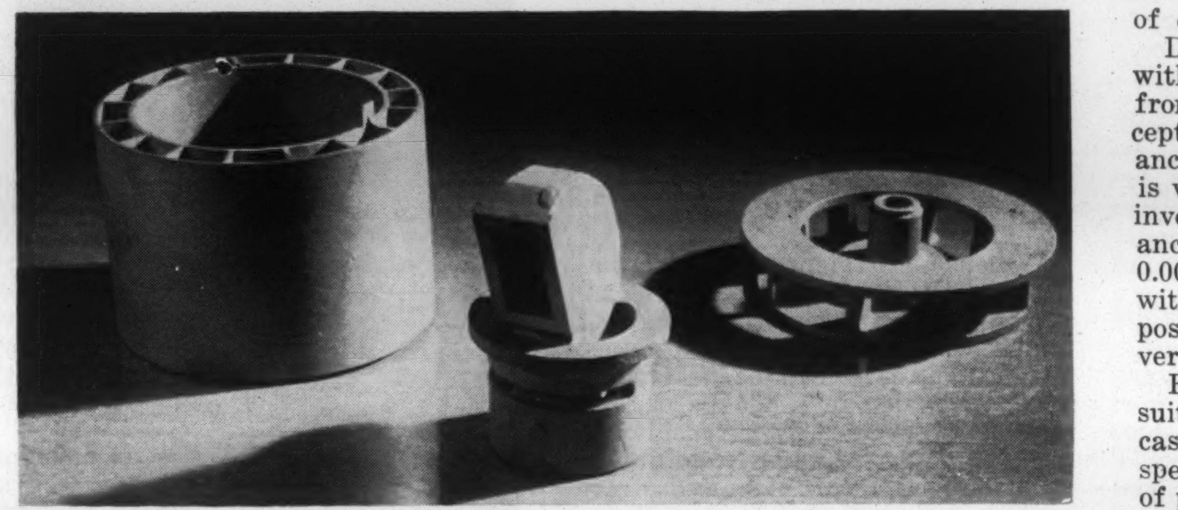
thereafter additional tolerances of ±0.001 in. be allowed for each additional inch of length.

Sizes of plaster mold casting usually fall within the range of ¼ lb up to 15 or 20 lb. Some heavier castings can be made, but the low strength of the plaster molds is such as to discourage the larger sizes.

One of the best features of plaster mold castings is that they can be made with extremely thin sections and walls. As a matter of fact, the process does not lend itself to shapes which require large masses of metal in any section. The most satisfactory section thicknesses range from 1/16 to ¼ in.

Materials

Plaster mold casting is limited to those metals with melting points below 2100 F. Most plaster mold castings have been made of the copper base alloys and primarily yellow brass, manganese bronze and aluminum bronze. Additional metals cast are the aluminum and magnesium alloys. Some authorities recommend that alloys containing more than 1.5% lead not be cast in plaster molds, although there is not universal agreement on this point. Those alloys which have some silicon content seem to pour best in plaster molds, particularly for parts requiring high surface detail. Magnesium pouring requires special techniques.



5. INVESTMENT CASTINGS

Investment castings, frequently referred to as precision castings, have a number of favorable characteristics which can be summarized by saying that they offer dimensional tolerances superior to the rougher castings processes, can be made in shapes too complex for powder metal parts and of materials with melting points too high for die castings.

The parts to be made are poured in molds which have themselves been cast in master molds. The mold materials can be plastics (usually polystyrene), wax or frozen mercury.

Patterns for individual parts are made by forming wax, frozen mercury or plastics (usually polystyrene) in a master die. The patterns are then covered with a ceramic material which is allowed to harden. When the ceramic shell has set, the investment material (wax, mercury or plastics) is melted out to leave the cavity for pouring the casting.

Each of the investment materials has some advantage. Wax permits the greatest flexibility of design and is the least costly. Plastics permit a more rapid production of patterns and also allows a surplus of patterns to be made and stored for future use. The frozen mercury allows larger sizes to be cast and requires only a thin ceramic shell which in turn results in better metal quality.

Design features

The mechanical properties of alloys cast in shell molds are high and in some cases equal to wrought metal properties. Parts to be made as investment castings can be quite complex. The chief restriction to complexity is the need to remove the pattern from the master die. With the investment materials used, small elements of a pattern can be formed separately and then joined before covering with the refractory material to attain the highest degree of complexity.

Dimensional tolerances possible with investment castings vary widely from foundry to foundry. Too, exceptionally close dimensional tolerances can be held if the customer is willing to pay for the extra work involved. The usual commercial tolerances are in the range of ±0.003 to 0.005 in. per in. of casting length, with closer dimensional control being possible on specific sections and with very small parts.

Extremely small parts are well suited to production by investment casting. Production of such parts is speeded by molding larger clusters of parts at one pouring. Most investment castings are in the weight range of a few ounces up to a maximum of 26 lb. Some shops using frozen mercury patterns are making much larger castings, however. By far the greatest number of investment castings are in the smaller sizes, weighing from 1 oz up to 3 or 4 lb.

Massive metal areas are not desirable in investment castings. Good design limits sections to 1 in. thick or less. Extremely thin sections, too, are to be avoided where possible.

Materials

The investment and shell mold casting processes are almost equal in the range of alloys which can be handled in that both can produce shapes in nearly any castable alloy. Somewhat better results are obtained with the nonferrous alloys with relatively low melting points because of their greater fluidity. The process is ideally suited to the high temperature alloys which are extremely difficult to machine and which are often required in shapes too expensive to generate by other methods.

6. DIE CASTINGS

Of all the casting processes, i.e. casting is by far the best suited to the high production of quality parts. There are some restrictions as to the metals which can be supplied as die castings and as to the complexity of the shapes produced, but other than that the process has much to offer.

Several types of die casting machines are used, some of them specifically for certain metals. All of them involve the forcing of carefully measured quantities of molten metal under pressure into closed dies. When small parts are involved, multiple cavity dies are used to multiply production rates. Most machines now in use are capable of handling a minimum of 100 shots per hour and some can be rated at even higher speeds. The high rates cannot be used on extremely large pieces, however, bcause of the longer times required to fill the dies, permit the metal to solidify and eject the finished parts from the machines.

The mechanical properties of die castings tend to be somewhat lower than the properties of identical metals in other cast or wrought forms. This situation can be charged chiefly to a slight porosity which results from the rapid freezing of the metal in the steel dies. Despite this, many die castings are used for applications where reasonably high mechanical strength is required. Usually the metal structure on the outside surfaces of die castings is excellent due to the formation of fine grained structures through rapid cooling.

Design features

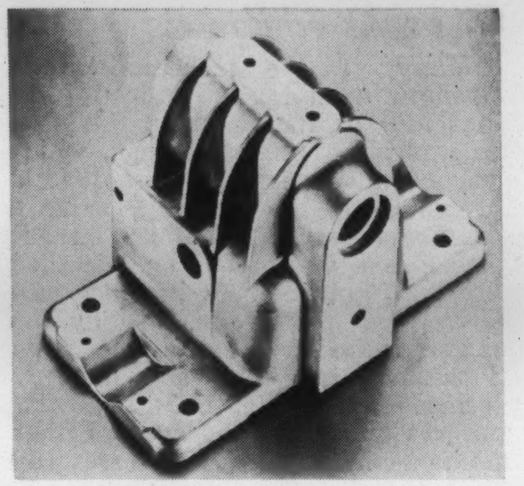
Generally speaking, the complexity of design of die castings is restricted because of the problem of removal of parts from solid dies. However, ingenious die design involving the use of complicated sliding die mechanisms can provide greater flexibility of design. Such die construction is expensive; thus, the savings expected through the reduction of further processing of the part would have to be great to justify the added expense. Most difficulty is encountered with undercuts and cross holes.

For many years die castings were considered for small parts only, but in recent years much work has been done on larger pieces such as the internal mechanisms of automobile doors and automotive engine blocks. If special machines are available, parts weighing as much as 75 lb in aluminum and 200 lb in zinc are practicable. Some die casters specialize in extremely small pieces and produce them at attractively low cost.

As with most processes in the precision group, die casting is capable of producing parts to extremely close tolerances. Again, within limits, nearly any degree of accuracy can be furnished if costs are no object. Ordinarily, the best tolerances are to be had with zinc die castings, and these are in the order of ±0.001 in. per in. of casting length. Somewhat more liberal tolerances must be allowed for other metals.

Minimum draft allowances of from 0.005 in. for zinc and 0.020 in. for copper-base alloys are required for removal of castings from the dies. More liberal allowances are desirable, however.

Large masses of metal are not good in die castings, and usually section thickness should be less than 1 in. In greater thicknesses, internal shrinkage can become a problem. On small parts, section thicknesses as low as 0.025 in. are possible. Minimum walls must be greater on larger pieces and with other metals. The surface finish of die castings is such that machining is seldom necessary.



With highly polished dies, a finish of 60 rms is possible, although ordinarily 100 to 125 rms is to be expected.

Materials

Most die castings are made of zinc, aluminum or magnesium, but some are produced in copper-base alloys, lead and tin. The relatively high melting point of copper-base alloys results in considerable die wear and, therefore, makes the process more expensive for these metals. Zinc has the advantage of taking plated coating readily without any preliminary work.

7. DROP FORGINGS

Drop forgings are made by hot billets of metal to approximately final form by repeated hammering with a suitable die held in a board, steam or air drop hammer. Often three dies are required to attain the final shape which is achieved by forcing the plastic metal into the die cavities in progressive stages. Flash, or surplus metal surrounding the finished forged shape is then removed in a trimming press.

The rate of output for drop forging is relatively low, with the best speeds being possible with low carbon steels. Rates are often estimated at 15 to 30 lb of forgings per hr per lb of falling weight of the hammer.

All forgings, but drop forgings in particular, are strong and tough, especially in the direction of the fiber flow of the metal. In this respect forgings are superior to most other metal forms.

Design features

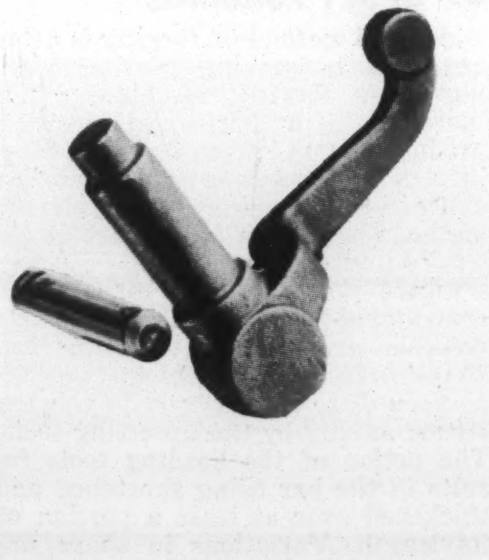
Although some forgings are as small as a few ounces, most are larger pieces. Draft allowances must be rather liberal and are higher in drop forgings than in press or upset forgings.

Design intricacy is restricted in forgings. No undercuts can be tolerated, and sudden, extreme changes in section thickness should be avoided. Generous radii are required. Holes in two places cannot be forged, so many shapes available as castings cannot be made as forgings. Likewise, depressions require projections on dies which are subject to breakage.

In striving for dimensional tolerances, allowances must be made with drop forgings for machining allowances and for cleaning which is required to remove heat scale. This is particularly true of steel forgings. On small parts, tolerances of ±0.010 to 0.015 in. can be held without difficulty. The closest tolerances can be achieved by the use of an additional coining operation.

Forgings, properly made, are free of internal defects such as blow holes or porosity which are common to some cast forms. For this reason, drop forgings have equal or greater strength and lower unit weight than parts made by castings or other methods of fabrication. However, production costs are high as to virtually eliminate drop forgings from consideration unless high quantities of parts are required. The high cost is due to die costs and to the fact that semi-skilled labor is required for forging.

Drop forgings can be made in all sizes, from those weighing a few ounces to hugh forgings weighing several tons. Large shapes are best made on steam or air hammers where extra pressure is available.



Small parts, where one blow of the hammer can produce the required deformation, are ideally suited to board hammers.

Materials

Straight carbon steels are the most frequently used as drop forgings because of the relative ease of forging. As the alloy content increases, forging becomes more difficult and more care and skill is required. Stainless steels fall in the latter group. Most nonferrous metals can be forged, and forging is usually specified when the strongest structure of the metal is desired. Brasses, bronzes, aluminum and magnesium alloys and titanium all find extensive use as drop forgings.

8. PRESS FORGINGS

Many of the mechanical and strength advantages of drop forgings also accrue to press forgings. In producing press forgings, which are also known as hot pressings, cold pressings or die pressed parts, a precut slug of the proper size is placed in a die impression and then pressed to make the metal flow into all recesses of the die. Usually the slug is heated for better metal flow. Sometimes the complete shape is formed in one die, but frequently progressive dies are used. Either mechanical or hydraulic presses can be used.

Parts made as press forgings are usually smaller than those made as drop forgings, although this is not always true with the light metals. When extremely small parts are involved, press forgings is usually preferred.

Design features

Press forgings can be somewhat more intricate in design than drop forgings, particularly with metals that are likely to extrude such as some of the brasses. In designing for press forging, parts should be provided with generous radii and fillets. Flowing lines help to assist the metal into the proper position and do not require die features that are costly and subject to breakage.

Most press forgings are of moderate size, weighing 25 to 30 lb or less. Larger sizes can be made provided that sufficiently large presses are available. Small sizes are well suited to press forging.

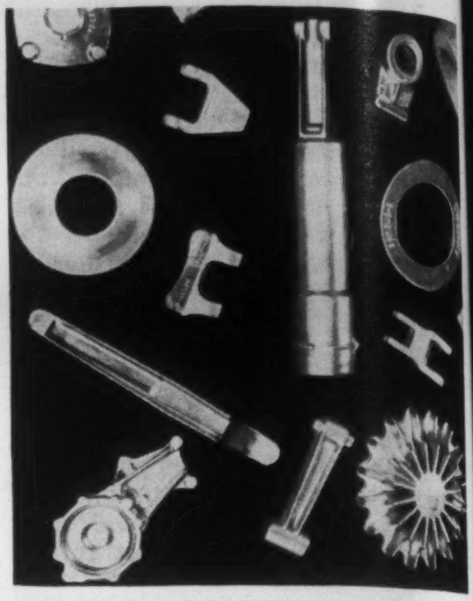
Tolerances on press forgings are somewhat better than on drop forgings, although they vary with the materials being forged and the design of the part. Commercially, tolerances of from ±0.030 to 0.010 in. can be attained without coining. With coining, tolerances of as little as ±0.005 in. can be held.

With most metals, draft angles of about 5 deg are needed to permit ready removal of parts from the dies. Exceptions are made with some shapes which can be ejected from the dies through the use of knockout pins and similar devices.

Materials

Materials used as press forgings can be divided into two groups, each having its own forging characteristics.

In the first group are the brasses and bronzes. These metals forge readily and thus can tolerate certain design variations not possible with metals that are more difficult to form. Because these metals, particularly the brasses, are inclined to extrude and flow readily, shapes made in these metals can have high ridges, deep pockets and projections as well as comparatively small fillets and radii.



In the second group are carbon and stainless steels, monel and other nickel alloys and aluminum and magnesium alloys. These groups are more difficult to forge and must conform to general forging restrictions as to design.

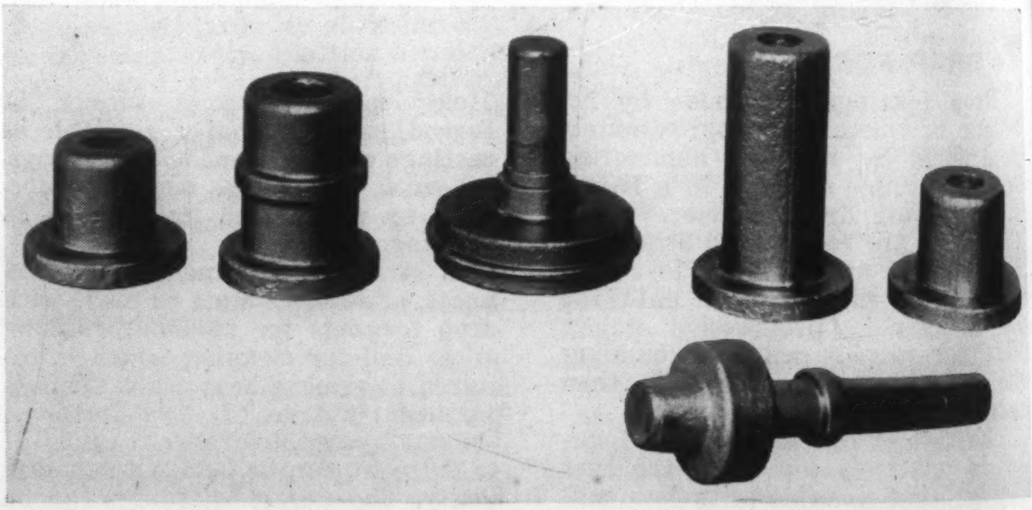
9. UPSET FORGINGS

A third method of forging is often employed in making medium sized parts. A forging machine, which operates in a horizontal position, produces parts known as upset forgings. The process is somewhat less expensive than the other forging methods because a large part of the work is automatic.

Upset forgings are made from round bars of metal, and the parts possible are limited to cylindrical shapes. The bar is held in two stationary dies, and the end of the bar struck axially by the upsetting tools. The action of the heading tools results in the bar being shortened and thickened over at least a portion of its length. Variations in shape are achieved by changing the heading and gripping dies. Progressive shifting is often used to attain a complete shape. If a pierced or hollow part is required, punches are used in place of heading dies.

Design features

Forging machines are made in sizes to handle bars from ½ in. dia up to 9 in. dia. Thus, parts produced on the smallest machines must have a minimum diameter of ½ in. Likewise, on the largest machines, the maximum diameter will be limited to a size which can be upset from a 9-in. bar. The length of bar to be upset cannot be greater than three times its diameter unless a great proportion of the length is contained in the gripper dies.



Tolerances attainable with upset forging are roughly comparable with those common to press forging. That is to say, from ±0.030 in. to 0.010 in. without coining. With coining, the tolerance can be reduced to ±0.005 in. on small pieces.

Draft allowances for upset forgings are midway between those of press forgings and drop forgings.

As indicated, shapes producible as upset forgings are limited to cylindrical forms. However, within this restriction more liberties in design are permitted than for the other forging methods. Thus, less liberal radii and fillets are possible. Undercuts can be formed readily. These are possible because the dies are removed from the pieces formed, rather than taking finished pieces from the dies as in other processes.

Hollow shapes are possible through the use of piercing tools during the sequence of forming operation. In some cases, the final desired shape can be formed and in others, machining requirements can be reduced considerably.

The finish in upset forging is likely to be less satisfactory than with other forging methods as there is a greater likelihood of pounding scale into the metal surface.

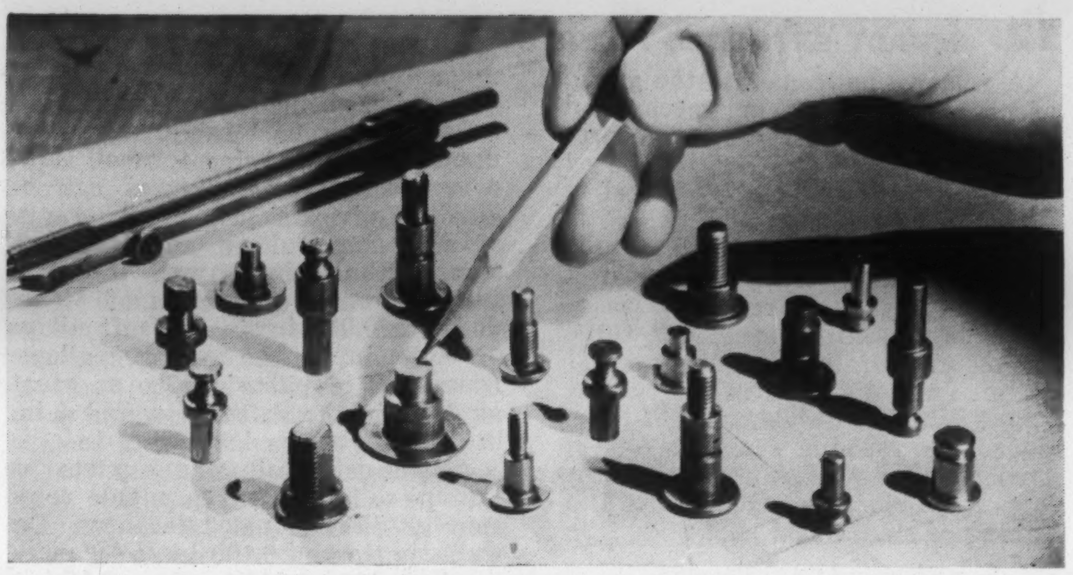
Materials

The metals suitable to upset forging are comparable to those used for press forgings. They include brasses and bronzes, carbon and stainless steels, nickel alloys and the light metals.

10. COLD HEADED PARTS

Cold headed parts are, in reality, a special form of upset forging in which cold drawn wire is used as the raw material and in which the forming is done cold. The process by which cold heading is done is highly automatic and is capable of extremely high production rates. The wire is fed from reels, automatically cut to proper length, fed to the dies and then shaped. The stock is held in dies and pressure is exerted on the end of the stock to force the metal into proper shape.

Because of the extremely high production rate which often reaches, or even exceeds, 400 pieces per minute, cold heading is a low cost process despite relatively high tool costs.



Design Features

The intricacy of design of parts made by the cold heading process is limited to cylindrical shapes as is the case with upset forging. The amount of upset is less than in hot forging. Collars as well as heads can be formed, but shapes of heads other than round are difficult to form. When hexagonal shapes, for example, are needed for bolts, a trimming operation is usually necessary to cut the hex from a circular head.

Shapes produced by cold heading are limited in size to those which can be formed from a 1-in. dia wire. Tolerances as low as ±0.002 in. are possible in the upset areas of cold headed parts, although those in the order of ±0.003 in. are more common. Tolerances on lengths, however, are seldom less than 1/32 in.

The surface finish of cold headed parts is superior to that produced by the forging processes, primarily because of the quality of the stock used and because the method does not require the use of heat.

Cold heading is best suited to the making of simple flanged or headed products such as bolts, screws and rivets or mechanical parts having similar contours. Wide, thin heads are not recommended nor are recessed heads. When fasteners are made by cold heading, threads are usually provided through a simple secondary roll threading operation.

Materials

Materials for cold heading must be quite ductile and available in cold drawn wire form. Metals that are too hard are likely to be brittle and crack during forming. At the other extreme, soft materials will become mushy and not form readily. In addition, the metals should have low work hardening rates. Included in the group that meet these specifications and which are most frequently used for cold headed parts are low and medium carbon and alloy steels, stainless steels, aluminum alloys, brasses and bronzes and many of the nickel alloys.

11. EXTRUDED SHAPES

Extruding, the art of pushing hot metal through restricted die areas, is being used increasingly as a means of making small parts of uniform cross section which might otherwise only be made through extensive machining. Long pieces of the desired shape are extruded and then cut to desired widths and subjected to any further operations which might be required to make the part usable.

Extruded shapes are not considered to be highly precise as far as dimensional tolerances are concerned, but they do have the advantage of permitting the metals to be placed where they are most needed to attain desired strength and design characteristics. Relatively complex shapes can be extruded as long as the cross section of the shape remains uniform throughout the entire length of the extrusion. Final dimensions, when precision is a requirement, are provided through machining. Extruding is sometimes used to make blanks for other processes, as for example, forging.

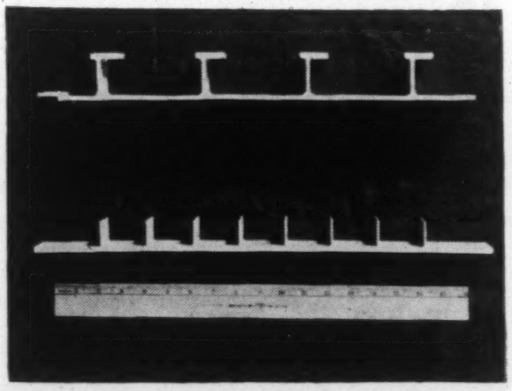
Design Features

Extruding is a simple means of obtaining complex shapes, and by its nature produces parts in which the metal used can be placed as desired without thought of how the extrusion will be removed from the dies. For example, sharp corners and reentrant angles are readily obtainable in extruded shapes. As in other metals forms, it is not wise to form extremely thin sections immediately adjacent to thick sections without providing generous fillets.

In addition to the restriction requiring the cross section to remain constant throughout the entire length of the extrusion, there is one other major limitation and that is the matter of size. Extruded shapes are usually restricted to those which can be contained within a circumscribing 17-in. circle. Within this range, parts can be made as solid, hollow or semi-hollow shapes, T, L or V sections, or rectangles and complex shapes.

Sizes are limited due to the excessive presses required to extrude sections larger than those indicated and because larger shapes than these are likely to bend and distort excessively under their own weight and require expensive straightening operations.

As indicated, extruded shapes are not produced to exceedingly close tolerances. Although tolerances vary among the materials extruded, these are representative: flatness, 0.024 in. on a 6 in. width; straightness, 1/16 in. deviation on a 5 ft length; cross section, 0.006 in. on thin sections, 0.080 in. on thick sections.



Materials

Although in the past most extruded shapes have been made from aluminum, magnesium and copper alloys, the process has recently been expanded to include many types of steels. Steels and other high melting point alloys are easy to extrude, but they are hard on die materials and require lubricants with special qualities. In addition to the materials listed, titanium, lead, tin and zinc alloys are also extruded. For best results there should be a great ratio of billet size to finish extrusion. Such ratios range from 20:1 to 40:1. When large ratios are used, the resulting extrusions are dense, homogeneous and free of porosity, and the metal properties compare favorably with those attained in forging.

12. IMPACT EXTRUDED PARTS

A relative newcomer to the group of processes for making mechanical parts is impact extruding. The process itself is old and has been used for many years to make collapsible tubes. In impact extrusion, which is also known as cold forging, cold extruding and extrusion forging, a slug of metal is placed in a press, and then pressure is exerted to force the metal literally to squirt around a punch and die to form the desired shape. With the development of techniques for forming stronger alloys, impact extruding has become an important production method for the making of mechanical parts.

Design features

Parts made by impact extruding cannot be exceedingly large or very small. They must be concentric in design but can be provided with lugs, flutes and similar projections. Mechanical properties of impact extruded parts are usually high because of the tremendous amount of cold work involved in the process. The latter feature is particularly true of carbon steels.

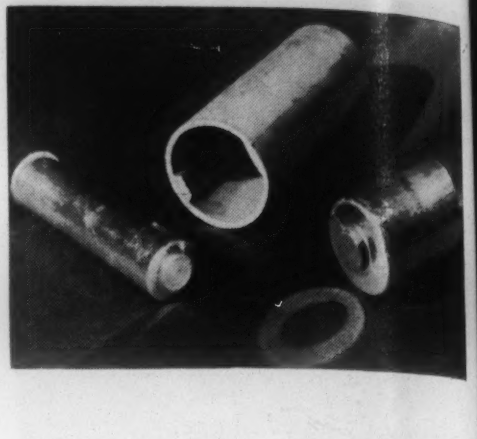
Often a concentric impact extrusion is sectioned after forming to make two or more parts which could not otherwise meet the design requirement of the method. Examples would be semi-circular parts or U-shaped pieces.

Part sizes and dimensional tolerances vary considerably, depending upon the metals being formed. However, some typical figures can be cited to give an idea of the range of sizes handled as impact extrusions. In aluminum wall thickness ranges from a maximum of ½ in. down to 0.010 in. in the soft alloys or 0.062 in. in the stronger alloys. Diameters of parts can be as great as 6 in. in the soft alloys and 4 in. in the hard alloys down to ¾ in.

Again using aluminum parts as examples, here are reasonable commercial dimensional tolerances. On walls as thin as 0.100 in., tolerances can be held to 0.010 in. Over 0.15 in., tolerances would have to be liberalized to 0.020 in. Diameters can be held to 0.010 in., but lengths are not usually guaranteed any closer than 3/16 in. For any material, the maximum size would be about 6 in. in dia and the minimum ¾ in. in dia. Above that maximum size, pressures would be extremely great, and in smaller sizes, tool damage could be excessive.

Materials

By far the most commonly used material for making impact extruded mechanical parts is aluminum and its alloys. More than a dozen different alloys are used depending upon the end service requirements of the parts. From the standpoint of extruding, though, the 1100 alloy is best.



In steels best results are obtained with those containing up to 1.2% carbon, although several alloy steels are being impact extruded regularly. Steel parts must be somewhat smaller and have greater wall thicknesses than similar parts in aluminum.

Magnesium slugs are heated to 500 to 700 F for impact extruding. Several different alloys can be used, but best results are obtained with alloy AZ31B.

Several other metals are being impact extruded, but to a lesser degree than those mentioned. They include lead, tin, copper, zinc and zirconium.

13. ROLL FORMED SHAPES

Certain shapes which are to be made of thin materials can be made by roll forming, although the method is somewhat restrictive as to the variety of designs that can be produced. Roll forming is done by feeding coiled metal into a machine which passes the metal through a series of rolls to form it progressively into the desired shape. As with extruded shapes, the final form must be of uniform cross section throughout the length of the piece.

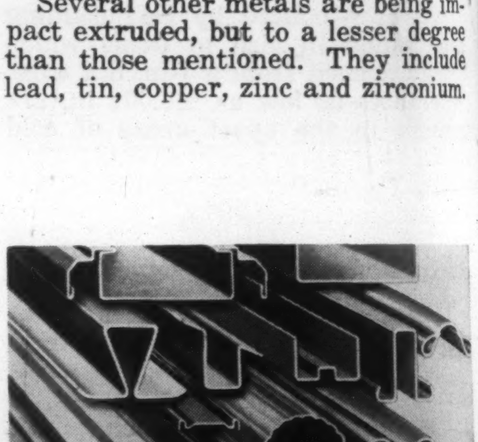
Shapes which are being produced by roll forming range from simple channels to lock-seam tubing. Due to high tooling costs for roll forming, the method is seldom practicable unless 25,000 ft or more of a single shape is anticipated.

Design features

Although roll forming is primarily intended for thin materials, shapes have been produced from materials from ½ to ¾ in. thick. Usually, however, the material used is less than 0.125 in. thick. As to width, the machines are capable of handling sheet and strip from a fraction of an inch in width up to as much as 80 in. wide, although most work is done with material less than 20 in. wide.

Dimensional tolerances must be comparatively liberal in roll formed shapes, primarily because of variations in the thickness of the raw material as it comes from the producers. Usually dimensional tolerances of ±0.002 to 0.015 in. must be allowed.

The surface finish of roll formed shapes is quite good because of the finish of the raw material fed into the machine. Some secondary operations such as shearing and piercing can be done on the roll forming machines to eliminate the need for additional handling of the stock.



Materials

The manufacture of roll formed shapes requires the use of ductile metals that submit to bending without too much springback. Cold rolled steel is the most commonly used material although with special preparations, unpickled hot rolled steel can be used. In addition, galvanized steel and other precoated materials have been formed. Some stainless steels, aluminum alloys and copper alloys are shaped by this method. Experimental work is now being done with titanium and zirconium.

14. STAMPINGS AND PRESS FORMED PARTS

One of the most commonly used processes for the making of parts and shapes for industrial uses is that of press working. Several variations of the process are known as blanking, pressing, stamping and drawing. All have certain similarities and all are done on hydraulic or mechanical presses or drop hammers. Involved in the processes are the preparation of a flat blank of sheet or strip metal and then shearing or deforming the metal in a die.

In the past, stampings and press formed parts could only be considered when huge quantities of parts were required. During ~~the~~ past few years, however, new techniques have been developed to extend the advantages of press forming to relatively small quantities of parts. Soft die materials, which are easily worked but have short service lives, can be used, as can rubber blankets or flexible punches or dies. Where the latter die materials are used, die costs are reduced sufficiently to permit amortization of costs over comparatively small quantities of finished shapes.

In making blanked shapes, usually flat, the metal is deformed beyond the shear point so that a clean break results. In drawing or forming, the stresses involved exceed the plastic limit of the metal so that permanent deformation results. When extreme draws are required, it is often necessary to draw part way, then anneal the part before taking a subsequent draw.

Design features

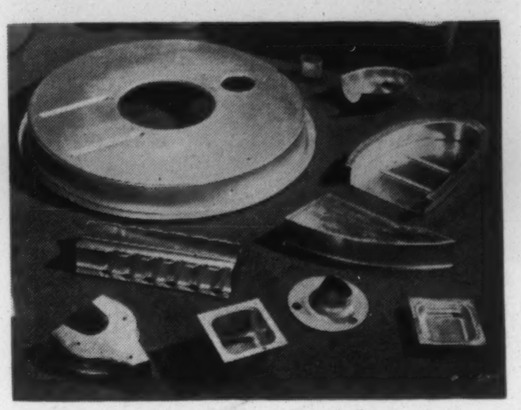
Stampings and press formed parts must be rather simple in shape as, for example, a perfectly flat blank such as a motor lamination or a shell with symmetrical contour. Flanges and other projections are costly to attain, and uneven shapes, too severe bends and other special features require die work that is too costly and often result in production difficulties.

As to dimensional tolerances, they vary with the thickness of the material being formed. Tolerances of ±0.001 in. are possible on small pieces and in the order of ±0.003 in. on large pieces. These tolerances apply primarily to thin sections. Tolerances must be more liberal for thicker sections. Stampings can be made with section thickness as fine as 0.003 to 0.005 in., but the majority of drawn and stamped shapes are made from thicker materials.

Relatively sharp corners are to be avoided in drawn shapes with minimum radii on bends at least equal to the thickness of the metal being worked.

Materials

Nearly any metal that can be rolled can be used for stampings and press formed parts, except that those materials that are essentially springy in nature should be avoided. Those materials now commonly used in these forms include carbon steels, copper, brass, bronze, aluminum and magnesium alloys, zinc, titanium, nickel alloys and some high alloy and stainless steels.



15. POWDER METALLURGY PARTS

Powder metallurgy is a process in which loose metal powders are compacted in a die and subsequently sintered to form a structural part. The process has certain limitations, but has the decided advantage of permitting the use of metallic combinations which would not be possible if melting were involved. In addition to permitting unusual metal combinations, powder metallurgy also permits close control over the structure of the compact, making it dense or porous as desired. Because powder metallurgy is not capable of holding extremely close dimensional tolerances, secondary sizing or coining operations are sometimes required.

Design features

Powder metallurgy parts are restricted to those of relatively simple shape. Complexity is restrained by the fact that dies must be made for easy removal of parts, because of the poor flow qualities of most powders, and the difficulty of transmitting pressures through great depths of powder. Where other considerations make it practicable, more complex shapes can be produced by using costly, intricate dies and double acting presses.

Cylinders, squares and rectangles are the best shapes to produce as powder metallurgy parts. When shapes deviate from these forms, it is essential that the design be such that it is of uniform shape in the direction of pressing. Contours must be in a plane at right angles to the direction of pressing.

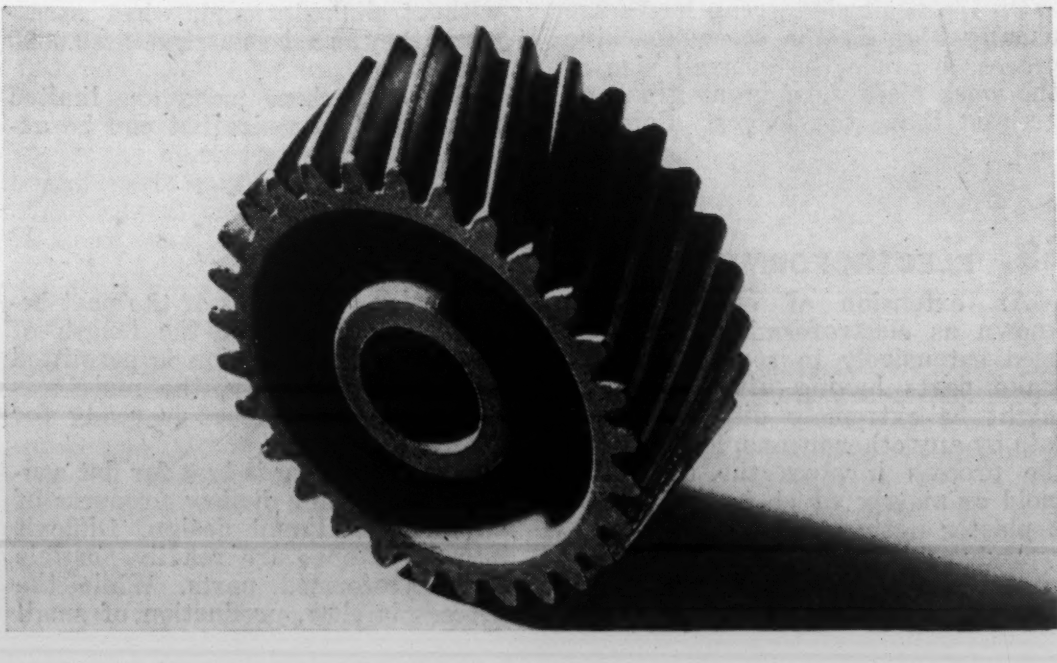
Feather or knife edges; narrow, deep splines; thin projections; and sharp corners should be avoided. Radii of at least 0.010 in. should be provided in corners, and edges should be given a 45-deg chamfer.

The size of powder metallurgy parts is restricted by press sizes and by the difficulty of transmitting pressing forces through large masses of powder. As to tolerances, ±0.001 in. are possible through coining and ±0.005 in. on axial dimensions without secondary operations.

Wall thicknesses as slight as 0.30 in. are possible on little parts, but a general rule calls for a minimum thickness of 0.32 in. per in. of length of the section. As with many other parts, large variations in section thickness are undesirable.

Materials

The materials which can be converted into powder metallurgy parts are probably more varied than for any other metal form. Material combinations impossible by other processes are commonplace in metal powder parts. Among the materials so formed are iron, steel, stainless steels, monel, nickel, iron-copper, copper, brass, tin, tungsten, zirconium and various oxides and carbides. The particle sizes of the powders used can be varied to achieve predetermined porosity and in combination with pressure variables, the density of the structure.



16. SPINNINGS

Spinning is a process for forming metal parts which involves the dishing of sheet metal disks, as they revolve on a lathe, by the use of simple tools which direct the metal over a wood or metal form. Simple shapes require the use of only one form while more complex shapes can be developed by using a series of forms.

Many of the shapes made as spinnings are comparable to those made by deep drawing, although spinning will permit somewhat greater complexity of design. When competition exists between the two processes, a final decision is usually reached based on the quantities of parts required. Spinning, being largely a hand operation, is practicabe only for relatively small quantities.

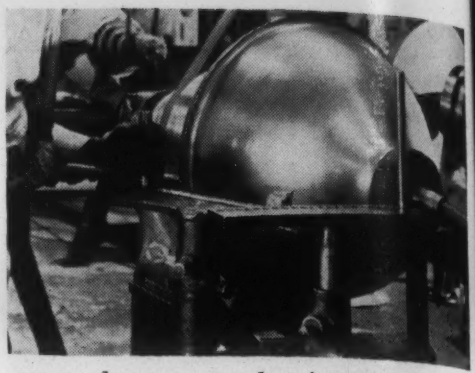
Design features

Spinnings must be concentric, round or cylinderical in shape. Within these limitations, the parts can have considerable complexity such as reentrant contours, necked-down ends and other deviations from a straight line which are virtually impossible to obtain in drawn shapes.

Tolerances on spun shapes can be closer than for sand castings, but are not as fine as in stamping or the precision metal forming processes. Ordinarily tolerances of ±0.015 in. can be held without any special handling. When closer tolerances are desired, they can be attained but the cost is high due to the amount of hand work and time involved.

Materials

Most metals can be spun, but the success of the operation is in direct proportion to the material's ductility. The best and most economical work is done with soft metals up to ¼ in. thick, stainless steels up to ⅛ in. thick and low carbon steel to 3/16 in.



Most commonly converted into spun shapes are aluminum and magnesium alloys, zinc, pewter, lead, mild steels, copper and copper alloys, nickel and nickel alloys and the 300 series and 430 stainless steels.

The actions required for spinning have two beneficial effects upon the materials being formed. First, the kneading action of the tools on the workpiece results in a fine finish which seldom requires any additional finishing operations. Second, the material work hardens during forming to give it additional strength and hardness.

17. SCREW MACHINE PARTS

As might be suspected, screw machines were once used almost exclusively for the manufacture of nuts, bolts, screws and other threaded fasteners. Today, however, screw machines are used to produce a variety of metal parts for all types of applications. Screw machines perform with amazing speed a range of machining functions including turning, forming, facing, drilling, threading and cutting-off. Control over the sequences is maintained by mechanical or electronic means.

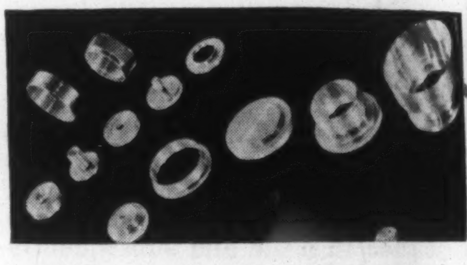
Perhaps the greatest advantage of screw machine parts is the extreme speed at which they can be produced. Production rates can reach—and even exceed—4000 parts per hour. Another advantage is the ability to maintain extremely close tolerances. Finishes are usually superior to those attained by other methods and, due to the fact that bar stock is used as the raw material, mechanical properties are usually high.

On the debit side, scrap losses are usually high in the screw machine process because the over-all size of the work piece must be as great, or greater than, the largest diameter of the finished part. In some cases there is a substantial recovery of the scrap loss through remelting of the turnings, but in others the recovery is slight.

Design features

As compared to parts made by several other production processes, screw machine parts are restricted as to complexity of design. However, compared to several others, design complexity is rather liberal. Restrictions are imposed by the requirement that all parts must have surfaces of rotation which are concentric with the axis of the stock being machined. However, interior and exterior undercuts are possible and nearly any type of thread can be produced on the part.

Square corners are not desirable. Chamfers are preferred, but if rounded edges are desired, liberal radii should be provided. Dimensions can be held to ±0.001 to ±0.003 in. without difficulty and, when necessary, they can be as close as 0.0005 in.



Screw machine parts are limited as to maximum size but can be extremely small. The range of sizes normally encountered goes from ¼ in. up to 8 in. in diameter and from a fraction of an inch to 6 to 8 in. in length.

Materials

Under certain conditions nearly any machinable metal can be used for screw machine parts if it is available in bar or tubular form. For best results, though, the material should be free machining and be neither too soft, too hard or too stringy. Materials of these types make it difficult to maintain production speeds and have considerable effect upon the surface finish obtained. Thus, the majority of screw machine parts are made from free-machining steels, free-cutting brasses and aluminum and magnesium alloys.

18. ELECTROFORMED PARTS

An extension of electroplating, known as electroforming, has been used extensively in recent years to make parts having attributes that might be extremely difficult to attain by any other means. Essentially, the process involves the use of a mold or matrix which is made from a plaster pattern of the part to be reproduced. The matrix is then placed in an electroplating bath and the part formed over the matrix by deposition. Thickness of the part becomes a function of the length of time the plating action is permitted to continue. Finally, the matrix is removed and the part is ready for assembly.

Electroforming is best for flat contour shapes and hollow products of any cross-sectional design. Difficult internal shapes are readily possible in electroformed parts. While the process is slow, production of small shapes can be increased by ganging of parts in the plating bath.

Among the advantages provided by the process are extremely thin sections, extremely smooth surface finishes on internal surfaces and the ability to duplicate exactly intricate surface detail.

Design features

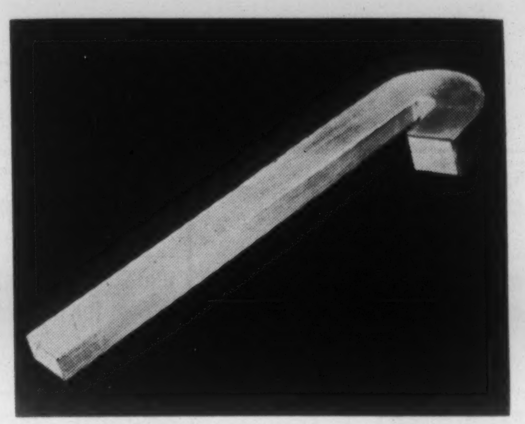
Dimensional tolerances of electroformed parts can be held to 0.002 in. without difficulty, although much of the control over dimensions is exerted by the original pattern and the matrix made from it. Likewise, surface finishes of the order of 5 micro-in. rms are possible if sufficient care has been exercised in preparing the patterns and matrices.

Wall thicknesses of electroformed shapes can vary from a few thousandths of an inch up to about ½ in. Naturally, the greater the thickness, the greater is the time required to build up that thickness through electrodeposition.

To assure uniform build-up of the electroplate, it is necessary that narrow, deep recesses be avoided. Usually, recesses are required to be as wide as they are deep.

Materials

Nearly any metal that can be electroplated can be used for electroformed parts. However, those used commercially are iron, copper, nickel and silver. For some uses, parts are built-up using layers of two or more metals to provide special physical or mechanical properties.



19. SECTIONED TUBING

In the strict sense of the word, the use of sectioned tubing cannot be included as a production process. However, the increasing use of parts made in this way forces it to be included in any report of this kind. In some respects, the use of sectioned tubing could almost be considered as a specialized use of extruded shapes, although much tubing made for this purpose is welded rather than drawn or extruded.

Tubing used as the raw material for small parts is made to closer dimensional tolerances than piping and is specifically intended for further processing.

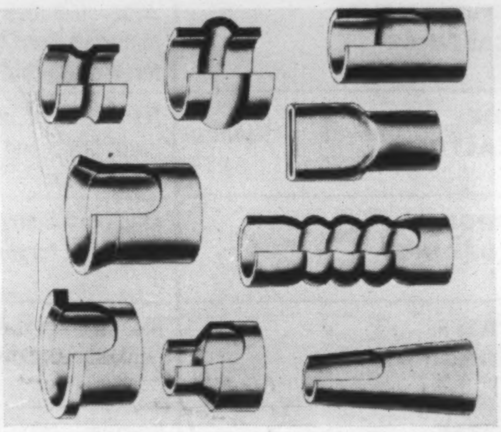
In converting tubing into mechanical parts, many operations are possible including plain sawing-off, swaging, bending, spinning, upsetting, flanging, flaring, expanding, flattening, sealing, beading, grooving and machining. Many of the desired shapes can be attained by using specially-shaped tubing which can reduce or eliminate further processing.

Tubing can be considered when the parts involved are long, thin-walled cylindrical shapes or for bushings, seals, retainer rings and other simple shapes.

Design features

Although tubing itself must be rather simple in shape and be of uniform cross section throughout its entire length, the parts made from tubing can be relatively complex, particularly when some of the subsequent forming operations are used. Dimensional tolerances vary widely and are largely dependent upon the quality and accuracy of the original tubing.

Tubing can usually be considered when the part to be made is hollow and particularly so when the part is open at both ends. In most cases the use of tubing can eliminate considerable machining.



Materials

Nearly any metal available as quality tubing could be used for the making of mechanical parts. Actually, most of the parts made through this method are made of carbon, alloy and stainless steels, aluminum and magnesium alloys and nickel and nickel alloys.

20. WELDED, BRAZED AND BONDED ASSEMBLIES

Whenever extremely complicated shapes are required, consideration should be given to welding, brazing or adhesive bonding as a means of joining together two or more comparatively simple shapes into a final permanent unit. By so doing, the advantages of several different processes can be combined in one piece. In addition, parts that might be too large for some of the ordinary processes can be made.

In many cases, stampings, spinnings or other sheet metal forms can be joined to cast shapes to attain sharp corners, extremely thin sections adjacent to thick sections and other design features which cannot be otherwise obtained because of the inherent limitations of many processes.

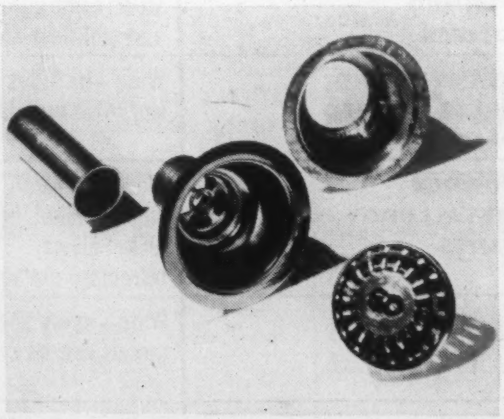
Design features

Actually there are no design limitations in the making of parts using welding and other joining techniques. Extremely complicated parts might require several bonding operations, but if the component could not be made any other way, the technique would be worth whatever the extra operations might cost. If there were any restriction, it might be in the matter of size. Extremely small parts might not be suited to the use of the welding processes if there were the possibility of burning through the metal or if the mechanics of handling the pieces were too involved.

Dimensional tolerances cannot be as close for assemblies of this type as for parts made by many other processes, although precise fixtures can be used to assure commercial tolerances in many cases.

Materials

With the widespread use of adhesive bonding, particularly where dissimilar materials are to be joined, there are now few limitations as to the materials which can be assembled by one or another of the joining processes. Caution must be used, though, in joining unlike materials to make certain that there is no possibility of galvanic couples being established between the materials.



DESIGN FEATURES

	Choice of Materials	Complexity of Part	Maximum Size	Minimum Size	Mechanical Properties
1. SAND CASTINGS	Wide—ferrous, nonferrous, light metals	Considerable—holes, bosses, locating pads	Great—largest forms made are sand castings	⅛-in. is smallest practicable section thickness	Fair to high depending upon metal being cast
2. SHELL MOLD CASTINGS	Wide—same as above except for low carbon steels	Moderate—limited by problem of removal of mold from pattern	Less than 60 in. square. Best for smaller parts	1/16 in. sections	Good—little porosity and gas inclusions
3. PERMANENT MOLD CASTINGS	Restricted—brass, bronze, aluminum, some gray iron	Limited—restricted by use of rigid molds	Moderate—50 lb is practical limit in aluminum	1 oz sections as thin as 0.1 in. can be cast	Fair—good in centrifugal castings
4. PLASTER MOLD CASTINGS	Narrow—brass, bronze and aluminum	Considerable—mold destroyed in removing part	Moderate—up to 15 lb in most materials	Small—1/32 in. sections possible	Fair
5. INVESTMENT CASTINGS	Wide—includes materials hard to forge or machine	Considerable	Moderate—best for parts under 2 lb.	Small—sections down to 0.030 in.	Good
6. DIE CASTINGS	Narrow—zinc, aluminum, brass and magnesium	Considerable—although costly dies might be required	Large—up to 75 lb in aluminum or 200 lb in zinc	Sections as small as 0.025 in.	Fair to good
7. DROP FORGINGS	Medium—many alloys are forgeable	Moderate—limited by die restrictions	Large	Small as pieces weighing a fraction of an ounce	High
8. PRESS FORGINGS	Medium—best for nonferrous alloys	Limited—but better than drop forging	Moderate—25-30 lb a practical maximum	Smaller than drop forgings	High
9. UPSET FORGINGS	Medium—many ferrous and nonferrous alloys	Limited to cylindrical shapes	Medium—9-in. bar about largest	Moderate—not comparable to casting processes	High
10. COLD HEADED PARTS	Narrow—confined to steel and highly ductile alloys	Limited—less flexibility than forgings	Small—7 in. by ½ in. dia usual maximum	Small—⅛ in. dia parts can be made	High
11. EXTRUDED SHAPES	Restricted—light metals, some steels, copper and titanium	Limited—can be complex in cross section only	Medium—8 to 10 in. dia maximum	Small—0.050-in. sections possible in aluminum and magnesium	Good
12. IMPACT EXTRUDED PARTS	Narrow—aluminum, magnesium, some steel	Limited—must be concentric	Small—6-in. dia in soft alloy 4-in. in hard	Moderate—¾ in. dia smallest	High—metals cold worked
13. ROLL FORMED SHAPES	Narrow—cold rolled steel; some aluminum and stainless steel	Restricted to thin sections and uniform cross-sections	Large	Sections from 0.125 in. up	Good
14. STAMPED AND PRESS FORMED PARTS	Wide—includes all workable metals	Limited—many design restrictions	Large—can be used on very large parts	Small—sections as thin as 0.003 in. possible	Fair to high
15. POWDER METALLURGY PARTS	Moderate—iron, steels, nickel, brass, nickel alloys, refractory metals	Limited—powders flow poorly and do not transmit pressures	Small—parts less than 4-in. sq best	Small—less than 1/16 in. dia possible	Fair to good
16. SPINNINGS	Wide—many sheet metals can be spun	Limited—Cylindrical or concentric shapes	Large—Up to several feet in diameter	Moderate—¼-in. in dia. in gages less than 0.040 in.	Good
17. SCREW MACHINE PARTS	Wide—best suited to highly machinable metals	Moderate—although limited to rotational shapes	Medium—Up to 6 in. long and 2½ in. dia	Small—under 1/16 in. dia	High
18. ELECTROFORMED PARTS	Narrow—iron, copper, nickel, silver	Great—extreme complexity possible	Limited—½ in. sections can be built up	Small—0.005 in. or less possible	Fair—lower than wrought
19. SECTIONED TUBING	Wide—any ductile metal available in tubular form	Limited by sectional shapes of tubing	Usually 4 to 6 in. o.d.	Moderate—¼ in. o.d.	Good—cold working improves properties
20. WELDED, BRAZED AND BONDED ASSEMBLIES	Wide—dissimilar metals can be joined	For extremely complex shapes	Unlimited	Moderate	Variable—depends upon components

DESIGN FEATURES (continued)

Precision and Tolerances	Special Structural Characteristics	Surface Smoothness	Surface Detail	Getting into Production	Rate of Output	Remarks
$\pm\frac{1}{16}$ to $\frac{1}{32}$ in. per in. normal, closer at extra cost	Good bearing structure	Poor	Poor	Moderate—patterns can be made in 3 to 5 days	25 to 600 pieces per hr depending upon size	Usually require some machining before use
±0.003 to 0.005 in. per in.	High quality for cast metals	Good	Good	Moderate—patterns might require several days	High, depending upon whether multiple cavity molds can be used	Considered best of low cost casting methods
$\pm\frac{1}{16}$ in. per in. in aluminum; better in brass	None	Good	Good	Moderate—several days to several weeks	Moderate—up to 100 per hr or more	Can achieve production economies when substantial quantities are involved
±0.010—0.005 in.	None	Good	Good	Moderate—several days to weeks	High—up to 1000 per hr depending upon size	Little finishing required
±0.005 in. per in. common	None	Excellent	Excellent	Fast—sometimes in a few hours	Moderate—depends upon size	Best for parts too complicated for other casting methods
±0.001 in. per in.	Special properties can be obtained through use of inserts	Good	Good	Moderate to slow—from one to several weeks	High—up to 1,000 per hr or more	Most economical where applicable
±0.010 to 0.030 in. without joining	Grain flow provides toughness	Fair	Fair	Slow—dies require much work	Medium—120 per hr. on small parts	Used where high strength is required
Medium—better than drop forgings	Hot working gives structural advantages	Fair	Fair	Slow	Medium—slower than drop forgings	Closer tolerances and greater complexity than drop forgings
Medium—compare to press forgings	Grain flow provides toughness	Medium	Medium	Slow	Medium	Best suited to small parts
±0.010 in. common; 0.002 in. possible	Tough structure	High	Fair	Fair—dies relatively simple	Extremely high	One of fastest processes
±0.005 to 0.020 in. common	Grain flow improves properties	Good	Only as part of contour	Moderate—dies relatively simple	High	Sometimes used as blanks for other processes
±0.001 in. are common	Grain flow improves properties	Good	Good	Moderate—dies relatively simple	High—up to 2000 per hr	Can eliminate machining
±0.002 to 0.015 in.	Cold work improves properties	Good	None	Slow—rolls require considerable time to make	High	Requires large quantities
Good—to ±0.001 in. common	None	High	Fair	Slow—dies might require several weeks	High—up to several thousand per hour	Usually low cost when quantities are sufficient
High—±0.001 to 0.005 in. common	Porosity can be controlled and complex materials formed	Fair	Fair	Relatively slow—dies require extreme care	High—up to 1,800 per hr common	Can use materials not formable by other processes
Fair—±0.015 to 0.060 in. common—better at added cost	Grain flow and cold work improve properties	Good	None	Fast—forms can be made quickly	Slow—12 to 30 per hr	Except for large pieces best on short runs
±0.001 to 0.005 in. possible	None	Excellent	Good	Moderately fast—depends upon operations	High—3,000 to 4,000 per hr on small parts	When materials and shapes agree, the fastest, cheapest method
High—±0.002 to 0.0002 in. common	Extremely dense structure; laminates possible	Excellent	Excellent	Slow—master might take several weeks	Slow—can be speeded by gauging	Best when complexity and accuracy are essential
Good—depends on quality of tubing	Grain flow improves properties	Good	None	Fast	High	Good means of reducing costs
Medium—not highly precise	Can combine parts with special properties	Depends upon components	None	Moderate	Varies as to joining process used	Often the only way to meet design requirements

COST FEATURES

	Raw Materials Costs	Tool and Die Costs	Optimum Hot Sizes
1. SAND CASTINGS	Low to medium, depending upon metal	Low	Wide range, from a few pieces to huge quantities
2. SHELL MOLD CASTINGS	Low to medium	Low to moderate	From a few to quantity production depending upon complexity
3. PERMANENT MOLD CASTINGS	Medium—nonferrous alloys used primarily	Medium	Large—best when requirements are in thousands
4. PLASTICS MOLD CASTINGS	Medium—nonferrous alloys only	Medium	100-2000 pieces best range
5. INVESTMENT CASTINGS	High—process best suited to special, costly alloys	Low to moderate depending upon a model being available	Wide, although best for relatively small quantities
6. DIE CASTINGS	Medium—mostly zinc, aluminum and magnesium	High—more than for other casting processes—$300 to $5,000 or more	Large—1,000 to hundreds of thousands
7. DROP FORGINGS	Low to moderate—steels up to high alloys	High—great care needed in dies—cost from a few hundred to several thousand dollars	Large—10,000 or more best quantities, although less can be justified
8. PRESS FORGINGS	Low to moderate—equal to drop forgings	High—usually less than for drop forgings	Medium to high production lots
9. UPSET FORGINGS	Low to moderate—as with other forging processes	High—often because of number of impressions or difficult design	Medium to high production lots
10. COLD HEADED PARTS	Low to moderate—chiefly steel wire	Medium—up to a few hundred dollars	Large—not suited to small quantities
11. EXTRUDED SHAPES	Moderate—primarily nonferrous metals, some alloy steels	Moderate	Moderate—500 lb billet smallest quantity
12. IMPACT EXTRUDED PARTS	Moderate—primarily aluminum and other low cost nonferrous metals	Medium—some dies less than $200	Wide range—from hundreds to thousands
13. ROLL FORMED SHAPES	Low to moderate—mostly low carbon steel sheet	High—several different rolls needed	High—should need 25,000 ft or more of one shape
14. STAMPED AND PRESS FORMED PARTS	Low to moderate—Ranging from carbon steel to stainless steel	High—$400 to $2,000 for small parts, more for large	Large—Over 10,000 best, although new processes permit smaller quantities
15. POWDER METALLURGY PARTS	Medium to high—powders relatively expensive	Medium—from $150 to $2,500	Large lots best (10,000) but small runs might be necessary
16. SPINNINGS	Low to moderate	Low—forms cost from $25 to $200 on ordinary work	Low—quantities under $1,000
17. SCREW MACHINE PARTS	Low to medium—seldom used on high alloys	Medium—from $50 to $200 common	Large—the larger, the better, over 1,000
18. ELECTRO FORMED PARTS	Low to high—iron to silver	High—mold last indefinitely, but must be perfect	Small—best when few pieces are needed
19. SECTIONED TUBING	High—25¢ per lb, or more	Low—cutting done with simple tools	Wide range—suitable for large or small quantities
20. WELDED, BRAZED AND BONDED ASSEMBLIES	Low to moderate	Low to moderate—simple jigs and fixtures	Small—although production brazing can handle large quantities

COST FEATURES (continued)

Direct Labor Costs	Finishing Costs	Scrap Loss
High—much hand labor required	High—require cleaning, snagging and machining	Moderate—foundry scrap can be remelted
Relatively low	Low—often only a minimum required	Low—little scrap generated
Moderate	Low to moderate	Low—most scrap can be reused
High—skilled operators necessary	Low—little machining necessary	Low—most is reusable foundry scrap
High—many hand operations required	Low—machining usually not necessary	Low—most scrap is remelted
Low to medium	Low—little more than trimming necessary	Low—gates, sprues, etc. can be remelted
Medium—skilled labor needed for heater and hammer work	Medium—especially with ferrous metals due to scaling	Moderate—depends upon quantity of machining required
Medium—less than drop forgings	Medium—same conditions as for drop forgings	Moderate—Usually less than for drop forgings
Medium—lowest of forging processes	Medium—often less than other forging processes	Medium—lowest of forging processes
Low—almost completely automatic	Low—	Low—practically none
Moderate	Low—	Low
Low—little skilled labor needed	Low—often none	Low—most loss in blanking scrap
Moderate	Low—cutting done automatically	Low
Medium—depending upon size and shape	Low—cleaning and trimming most frequent	Low to moderate
Moderate—some skilled labor needed	Low—machining seldom needed	Low—practically no scrap
High—skilled craftsmen needed	Low—restricted to cleaning and trimming	Moderate—most comes in cutting blanks
Low—one operator can handle several machines	Low—cleaning and deburring	High—generates large quantities of chips
Medium to high—both skilled and unskilled labor needed	Low—no subsequent finishing	Low—little, if any, scrap
Low—skilled labor not needed	Low—generally	Low—practically none
Medium to high—skilled labor needed	Medium—joints must be cleaned	Low—practically none

METAL FORMS AND THE MATERIALS COMMONLY USED

Material	Physical Properties				Atmospheric Corrosion Resistance	Forms in which commonly used for fabricated parts
	Melting Point, F	Specific Gravity	Tensile Strength, psi	Yield Strength, psi		
LOW CARBON STEELS	2750-2800	7.8-7.9	50,000-120,000	30,000-90,000	Fair	**1, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20**
HIGH CARBON STEELS	2600-2750	7.8	100,000-200,000	75,000-175,000	Fair	**1, 2, 5, 7, 8, 9, 13, 14, 16, 17, 19, 20**
HIGH ALLOY STEELS	2500-2750	7.8-8.8	80,000-250,000	50,000-210,000	Fair	**1, 2, 5, 7, 11, 14, 19, 20**
TUNGSTEN CARBIDE	2700	14-15	transverse rupture strength 125,000-400,000		Good	**15, 20**
STAINLESS STEELS	2500-2800	7.4-8.0	100,000-220,000	50,000-125,000	Excellent	**1, 2, 5, 7, 8, 9, 10, 13, 14, 15, 16, 19, 20**
IRON	2100-2400	7	25,000-120,000	Up to 60,000	Fair	**1, 2, 3, 15, 18, 20**
COPPER	1980	8.9	23,000-52,000	14,000-50,000	Good	**1, 2, 3, 5, 11, 12, 13, 14, 15, 16, 18, 19, 20**
BRONZES	1800-1950	7-9	40,000-200,000	20,000-175,000	Good	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 20**
BRASSES	1720-1950	8.4-8.8	30,000-40,000	15,000-50,000	Good	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 19, 20**
NICKEL-BASE ALLOYS	2200-2600	8.3-8.9	60,000-100,000	30,000-80,000	Excellent	**1, 2, 5, 7, 8, 9, 10, 11, 14, 15, 16, 18, 19, 20**
NOBLE METALS	1750-3600	10-21.5	23,000-150,000	12,000-80,000	Excellent	**5, 14, 17, 18, 20**
ZINC AND ITS ALLOYS	727-785	6.6-7.1	15,000-45,000	10,000-25,000	Good	**3, 6, 11, 12, 14, 16, 20**
LEAD	300-625	10.5-11.5	2000-12,000	1000-10,000	Good	**3, 6, 11, 12, 16, 20**
TIN ALLOYS	360-470	7.3-7.8	2000-15,000	1300-9800	Good	**6, 11, 12, 15, 20**
ALUMINUM AND ITS ALLOYS	940-1225	2.6-2.9	13,000-75,000	5000-65,000	Good	**1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19, 20**
MAGNESIUM AND ITS ALLOYS	815-1200	1.74-1.9	13,000-65,000	3000-50,000	Good	**1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 16, 17, 19, 20**
TITANIUM ALLOYS	3020-3135	4.51	60,000-195,000	55,000-165,000	Excellent	**7. 11, 13, 20**

*1. *Sand Castings*
2. *Shell Mold Castings*
3. *Permanent Mold Castings*
4. *Plaster Mold Castings*
5. *Investment Castings*
6. *Die Castings*
7. *Drop Forgings*
8. *Press Forgings*
9. *Upset Forgings*
10. *Cold Headed Parts*
11. *Extruded Shapes*
12. *Impact Extruded Parts*
13. *Roll Formed Shapes*
14. *Stampings and Press Formed Parts*
15. *Powder Metallurgy Parts*
16. *Spinnings*
17. *Screw Machine Parts*
18. *Electroformed Parts*
19. *Sectioned Tubing*
20. *Welded, Brazed and Bonded Assemblies*

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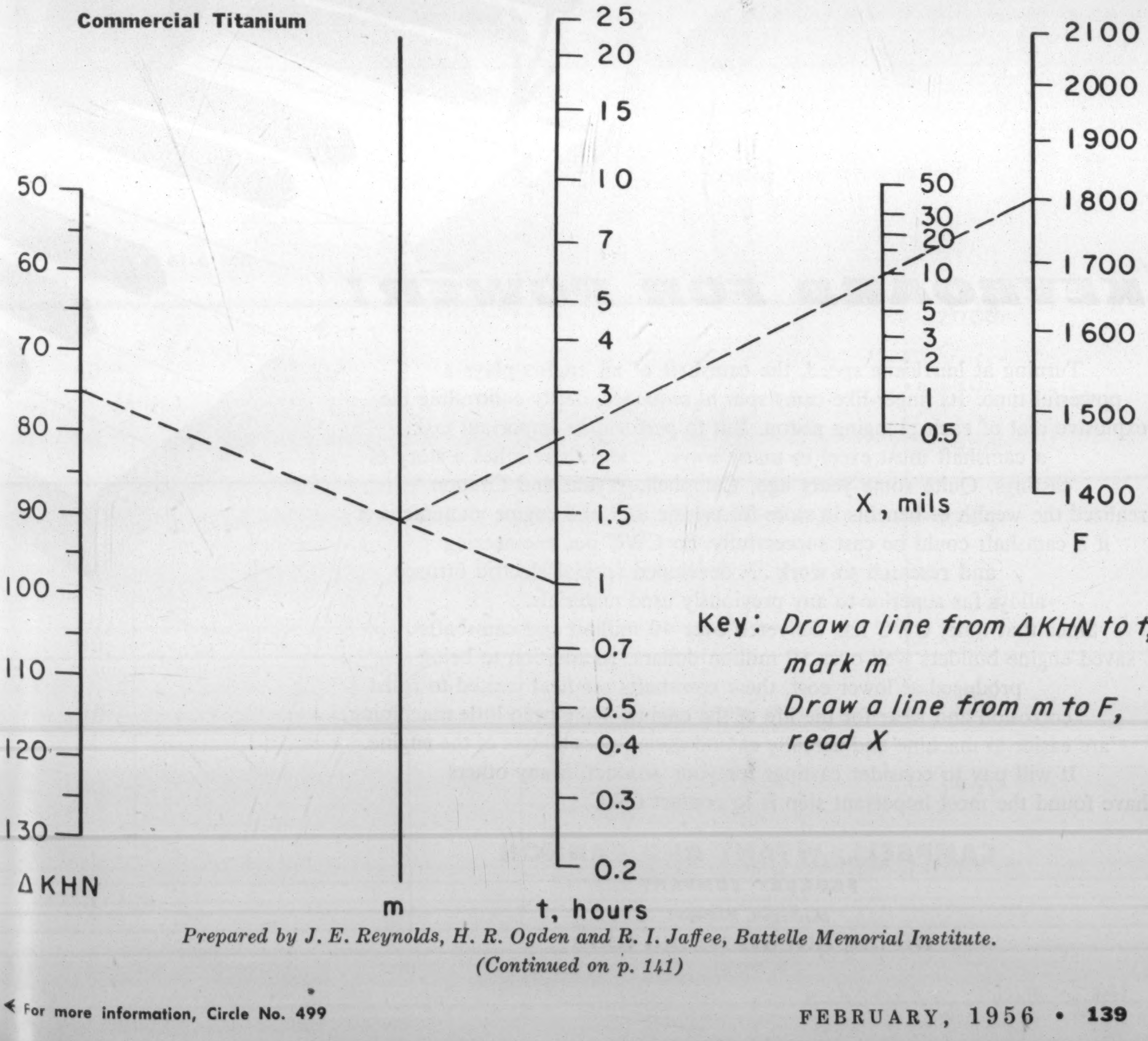
MATERIALS ENGINEERING FILE FACTS

Nomographs for Calculating Hot-Air Contamination of Commercial Titanium and Titanium Alloys

The contamination of titanium and its alloys in air poses a problem of particular importance with regard to their hot working and/or heat treatment because the contaminants absorbed (chiefly oxygen) embrittle the surface layers, which may crack and subsequently cause bulk failure. The following nomographs were constructed from experimental diffusion studies and apply to conditions in which contamination does not extend throughout the section involved. From these charts, one may calculate depth of contamination of the metallic surface in air for the times and temperatures covered.

To use the nomographs, select a hardness increase representing a tolerable level of contamination. The contamination has been expressed as an increase in Knoop hardness number (ΔKHN) so that the data will be applicable to alloys varying somewhat in their base hardnesses. Example: Tolerable increase in hardness 75 Knoop hardness points (ΔKHN=75). Alloys heated for 1 hr at 1800 F in air. Determine depth of contamination. Following the key on the nomographs, contamination (hardness increase 75 Knoop points) extends to approximately 10, 7, and 4 mils for commercial titanium, Ti-4Al-4Mn, and Ti-5Al-2.5Sn, respectively.

Information obtained from research conducted at Battelle Memorial Institute for the General Electric Co., pursuant to its Prime Contract No. AF 33 (600)-21277 with the Air Force, Wright-Patterson Air Force Base.



Commercial Titanium

Key: *Draw a line from ΔKHN to t, mark m*

Draw a line from m to F, read X

Prepared by J. E. Reynolds, H. R. Ogden and R. I. Jaffee, Battelle Memorial Institute.

(Continued on p. 141)

CWC
Since 1908

KEYBOARD FOR POWER!

Turning at hurricane speed, the camshaft of an engine plays a powerful tune. Its finger-like cams spin in sequence, deftly controlling the explosive diet of each plunging piston. But to perform its important task, a camshaft must excel in many ways . . . and therein lies a story of castings. Quite some years ago, Campbell, Wyant and Cannon realized the wealth of benefits in store for engine user and engine manufacturer if a camshaft could be cast successfully. So CWC put engineering and research to work . . . developed special electric furnace alloys far superior to any previously used materials.

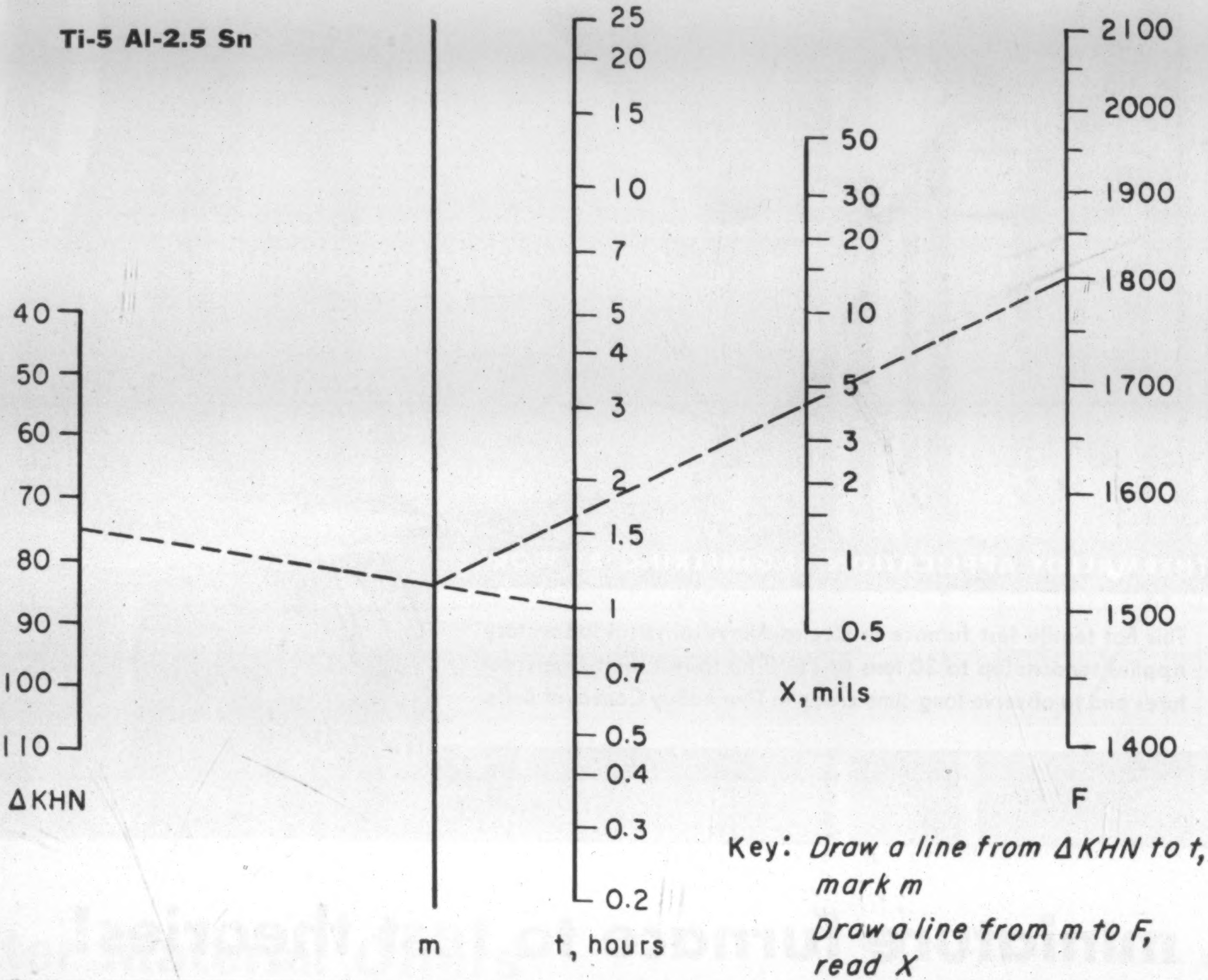
Since that time, CWC has delivered over 40 million cast camshafts . . . saved engine builders well over 50 million dollars. In addition to being produced at lower cost, these camshafts are heat treated to resist corrosion and wear for the life of the engine. They need little machining, are easier to machine and actually extend design possibilities of the engine.

It will pay to consider castings for your product. Many others have found the most important step is to contact CWC.

CAMPBELL, WYANT AND CANNON
FOUNDRY COMPANY
Muskegon, Michigan
GRAY IRON, ALLOY IRON AND STEEL CASTINGS

NOMOGRAPHS *continued from page 139*

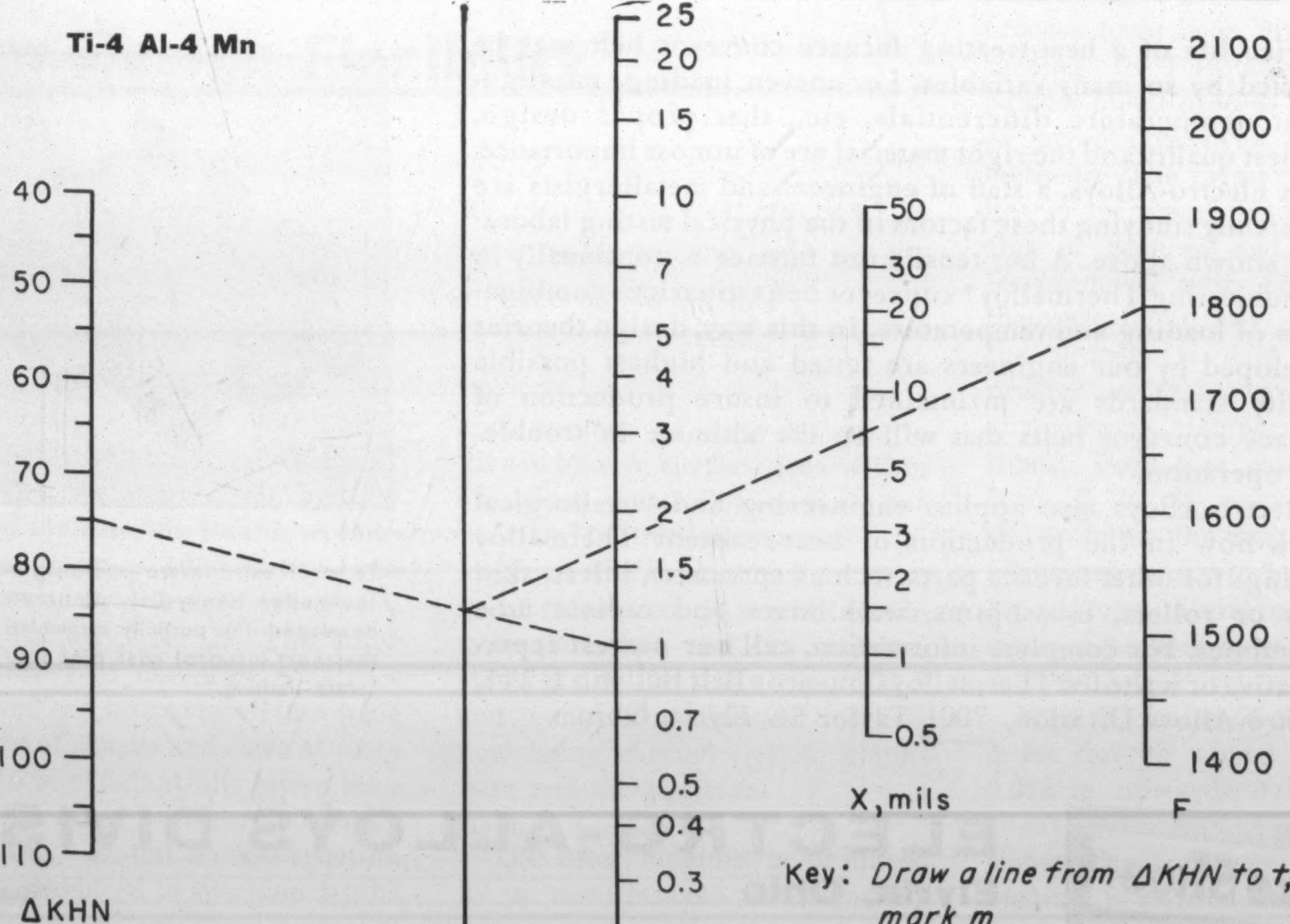
Ti-5 Al-2.5 Sn



Key: *Draw a line from ΔKHN to t, mark m*

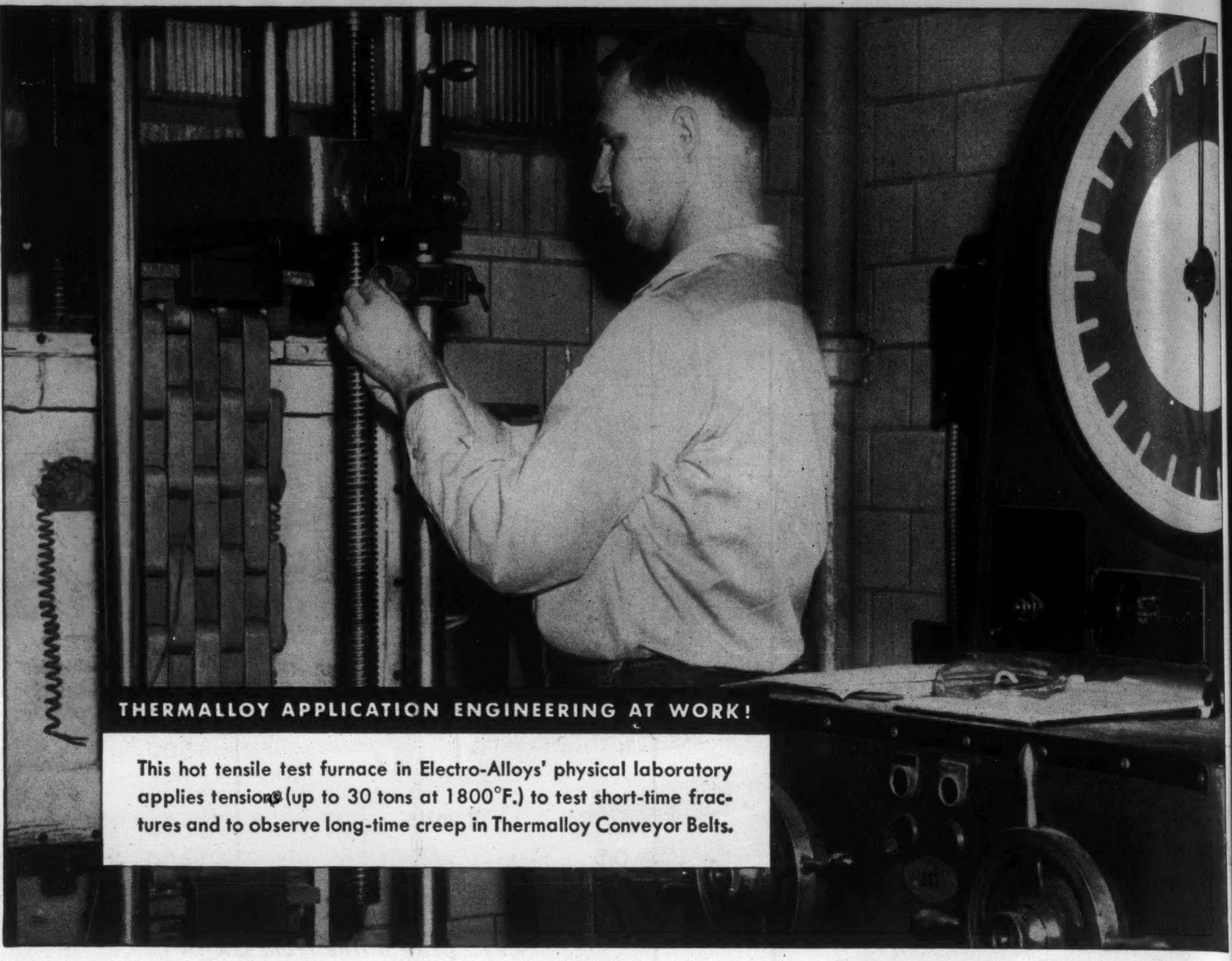
Draw a line from m to F, read X

Ti-4 Al-4 Mn



Key: *Draw a line from ΔKHN to t, mark m*

Draw a line from m to F, read X



THERMALLOY APPLICATION ENGINEERING AT WORK!

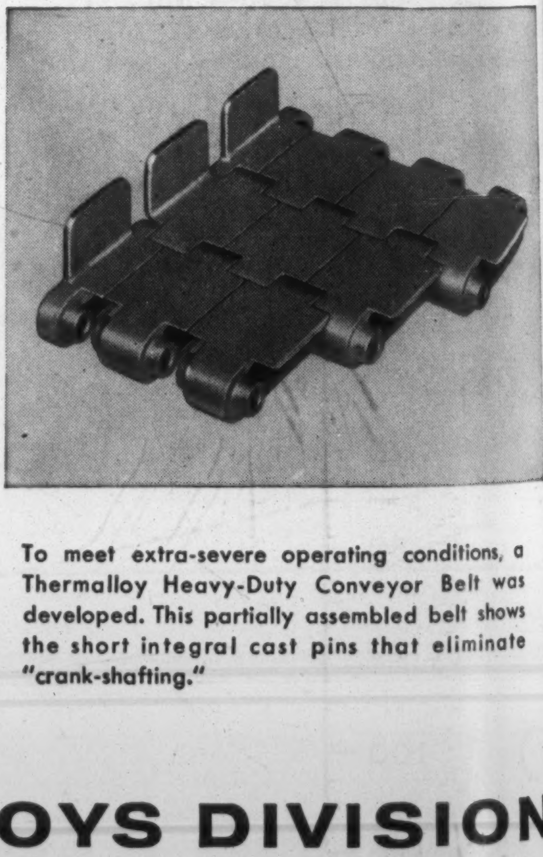
This hot tensile test furnace in Electro-Alloys' physical laboratory applies tensions (up to 30 tons at 1800°F.) to test short-time fractures and to observe long-time creep in Thermalloy Conveyor Belts.

A miniature furnace to test theories!

Service life of a heat-treating furnace conveyor belt may be affected by so many variables, i.e. uneven loading, misalignment, temperature differentials, etc., that proper design, highest quality and the right material are of utmost importance.

At Electro-Alloys, a staff of engineers and metallurgists are constantly studying these factors in the physical testing laboratory shown above. A hot tensile test furnace is continually in use subjecting Thermalloy* conveyor belts to various combinations of loading and temperature. In this way, design theories developed by our engineers are tested and highest possible quality standards are maintained to insure production of furnace conveyor belts that will be the ultimate in trouble-free operation.

Electro-Alloys also applies engineering and metallurgical know-how in the production of heat-resistant Thermalloy castings for other furnace parts such as sprockets, idlers, skid rails or rollers, crossbeams, wall boxes and radiant tube assemblies. For complete information, call our nearest representative or write for Thermalloy Conveyor Belt Bulletin T-241, Electro-Alloys Division, 7001 Taylor St., Elyria, Ohio.



To meet extra-severe operating conditions, a Thermalloy Heavy-Duty Conveyor Belt was developed. This partially assembled belt shows the short integral cast pins that eliminate "crank-shafting."

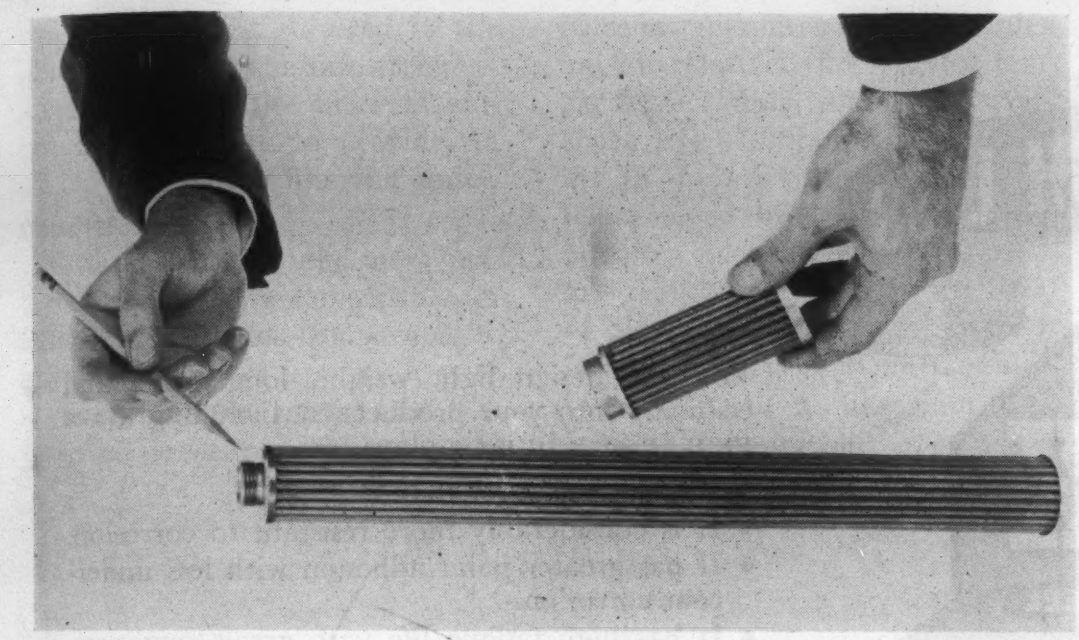
AMERICAN **Brake Shoe** COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

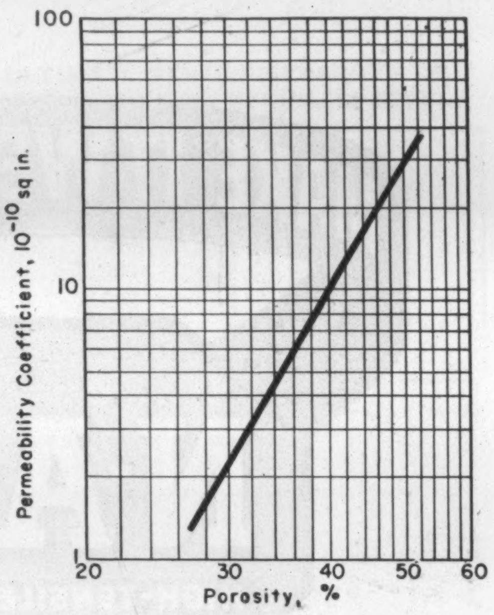
*Reg. U. S. Pat. Off.

For more information, turn to Reader Service Card, Circle No. 416

NEW MATERIALS PREVIEWS



Filter elements *of the new porous material can be made in a variety of lengths and sizes.*



Permeability vs porosity of new sintered material.

Filter Material Offers New Design Flexibility

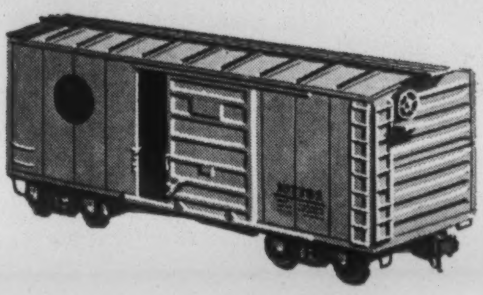
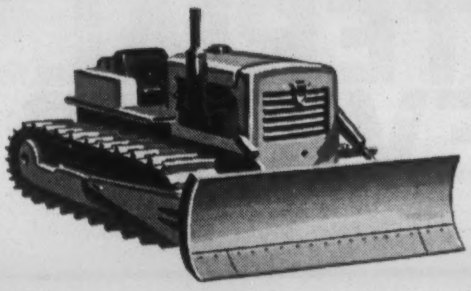
Produced by a new process, these metal powder shapes combine good corrosion resistance with controlled permeability and satisfactory service up to 1000 F.

■ A sintered porous metal filter material, available in a variety of corrosion resistent alloys, and designed for filtering liquids at temperatures up to 1000 F has been announced by *Purolator Products, Inc.*, Rahway, N. J. The filter medium is of one-piece construction and can be produced in a wide variety of shapes and sizes at costs said to be substantially lower than those of other powder metallurgy processes. Radial fin construction can be produced to specified depths and number of convolutions to give extensive surface area within a confined space. For example, one unit 1¾ in. in diameter and 5 in. long can contain as much as 80 sq in. of filter area. It is available in types 304, 347, and 446 stainless steels and in Hastelloy, pure nickel and monel. Experimental work is now being carried out on aluminum and nickel-silver.

Design factors

The filter medium is produced by a new process developed by Purolator in cooperation with Horizons, Inc. No details of the process have been disclosed. According to Purolator, the new powder metal process offers several advantages over conventional methods. The primary advantage lies in increased flexibility of design at reduced cost. Parts can be produced with no draft and theoretically in any shape. Also, the process is said to provide greater control over processing atmospheres, temperatures and times. Pore size can be altered from 2 to 25 microns, though the optimum for most present applications seems to be about 8 to 10 microns. Uniformity of pore size can be held to within ±10%, according to Purolator.

Wall thickness of the filter medium can be varied from about 0.015 in. upwards, 0.030 in. being about optimum for most applications. The endshape of the filter medium is as-produced by the new

MAKE IT WEIGH LESS

N-A-X

HIGH-TENSILE STEEL

MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel—it can be cold formed as readily into the most difficult shaped stamping.

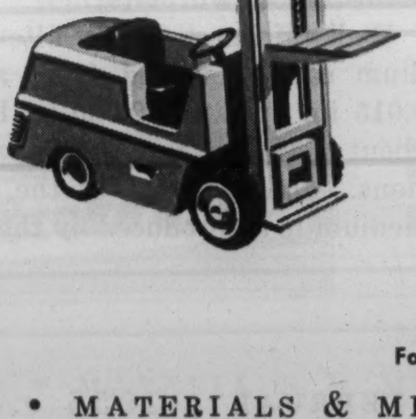
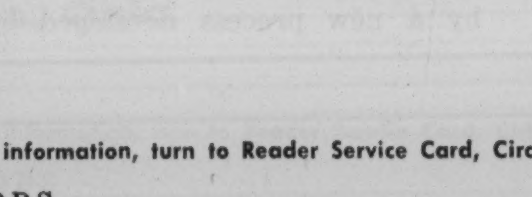
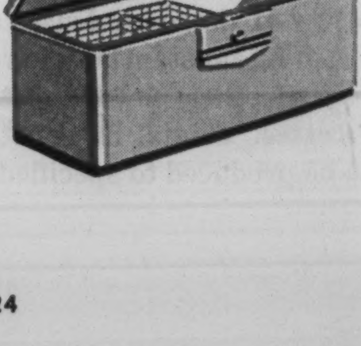
When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service Card, Circle No. 424

NEW MATERIALS PREVIEWS

process. The only subsequent fabrication operations are attachment of fittings and reinforcing rings. These are sintered to the filter material at the same temperature at which the filter is sintered, and is said to provide, in effect, a one-piece filtering unit.

Conditions of use

Filters made of the new material are said to be capable of handling flow rates comparable to any high temperature filter, with lower differential pressures. Differential pressures may range up to 500 psi. Originally intended for aircraft hydraulic systems, the filters were designed to replace organic filter elements which have a relatively low service temperature ceiling, and a relatively short life. Contaminants collecting in the new filter material can be removed by back-flushing, or burning out. The new elements are only about twice the weight of older type organic filters. For example, one type of fibrous filter element, with a maximum temperature limitation of 400 F weighs 88 g, while a comparable element with the new filter medium weighs 150 g.

In addition to the aircraft industry, the filters are expected to find wide application in the chemical process, atomic energy, guided missile and petroleum industries. It should also find uses in general industrial and food fields, wherever critical corrosion or high temperature conditions prevail.

ULTIMATE TENSILE STRENGTH OF POROUS TYPE 302 STAINLESS STEEL[1]

U.T.S, psi	Porosity, %
7500	50
13,500	40
22,000	30
36,000	20

[1] *Permeability coefficient λ is proportional to the 5.1 to 5.5 power of the porosity.*

Two other types of porous metal

Two other types of filter material in the form of sheet metal have recently become available. One is an expanded metal, the other a perforated sheet. Good strength and close control over pore size and location and shape of openings are claimed for both.

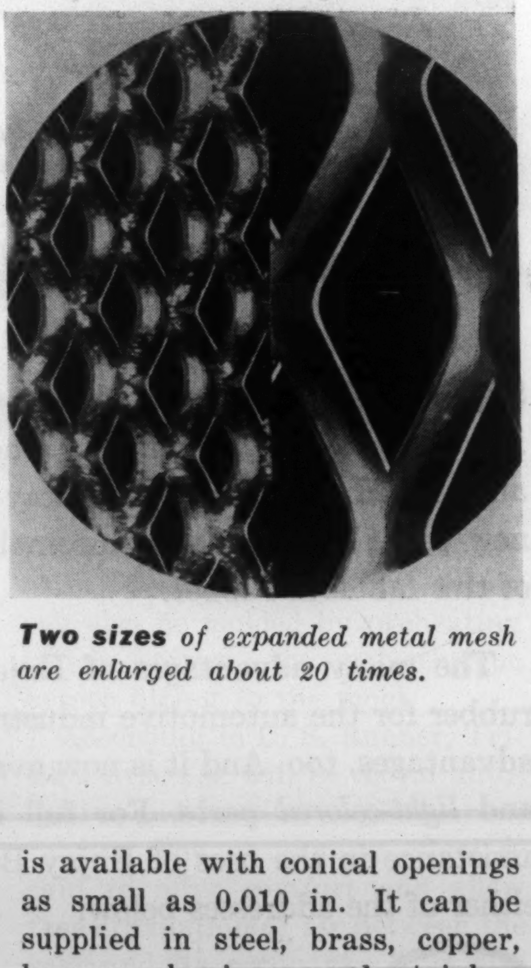
Expanded metal

Expanded metal consists of rolled sheet metal cut and expanded into diamond-shaped meshes with the junctions between openings remaining uncut. A new process for expanding metal to form openings as small as 0.0157 by 0.0295 in. has been developed by Le Metal Deploye in France. The material is being supplied in North America by the *Le Metal Deploye, c/o J. P. Spire*, 3877 Draper Ave., Montreal 28, Canada. It is available in various metals, such as mild steel, stainless steel, brass, copper, aluminum alloys and nickel. Sheets are produced in bands up to 5.9 in. wide and 6.56 to 9.84 ft in length. Mesh is available with four sizes of openings: 0.0157 by 0.0295 in., 0.0236 by 0.0393 in., 0.0393 by 0.059 in., and 0.787 by 0.1181 in.

Perforated sheet

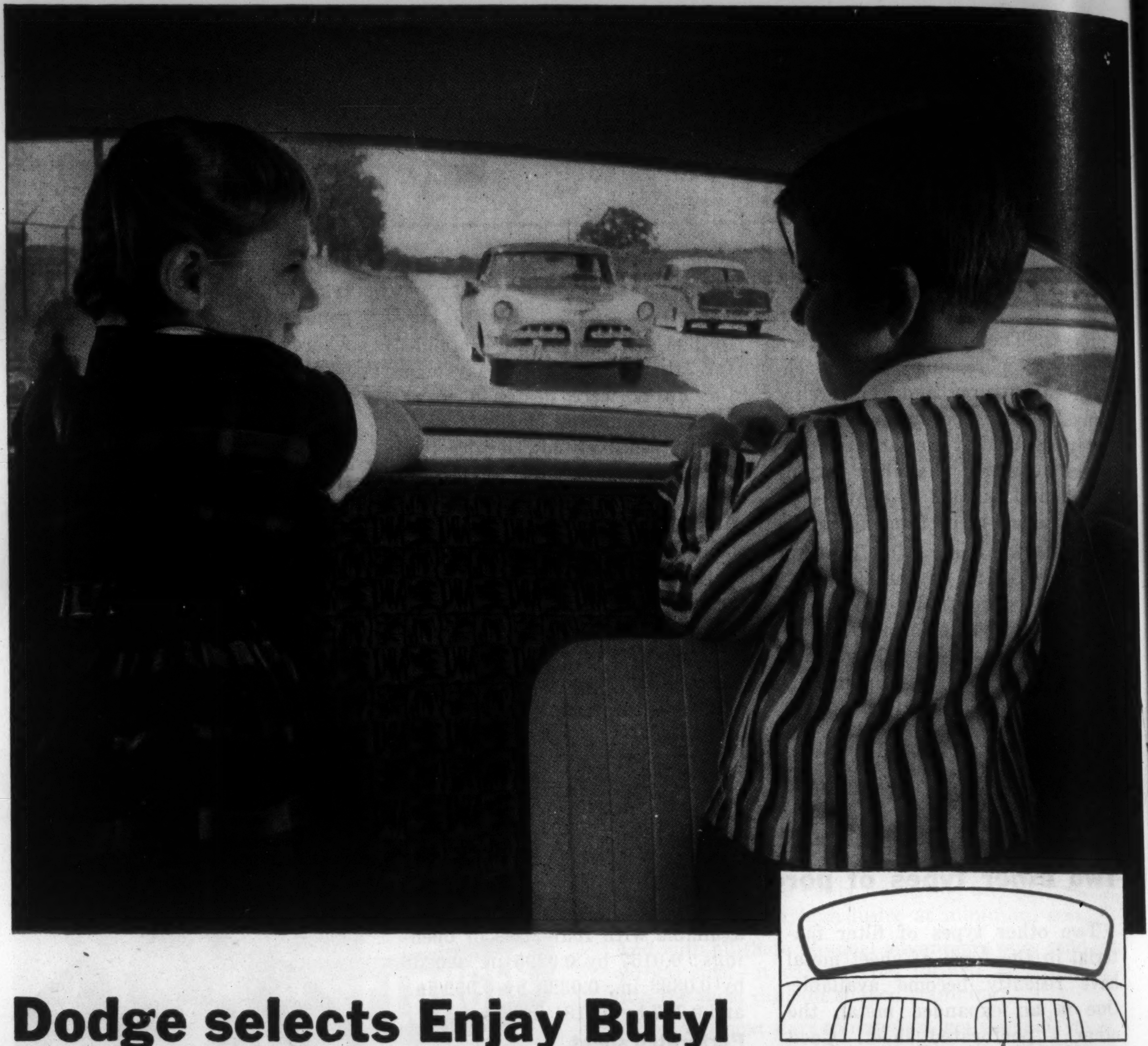
Accuracy of opening size and rigidity of construction are claimed for perforated sheet formed either electrolytically or mechanically by *Pyramid Screen Co.*, 264 Mason Terrace, Brookline 46, Mass. Electrolytically perforated plate is available with openings as small as 0.00078 in. (about 20 microns). Holes are round, square or oblong in shape. Holes may be conical or venturi shaped in cross-section. Sheet is available in pure nickel, pure copper or other base metals. Plate thickness ranges from smaller than hole diameter to several times the diameter. Standard size of plate is 39 by 39 in., or it is available cut to size requirements. Continuous sheet should be available shortly.

Mechanically perforated sheet is available with conical openings as small as 0.010 in. It can be supplied in steel, brass, copper, bronze, aluminum and stainless alloys.



Two sizes *of expanded metal mesh are enlarged about 20 times.*

(More Previews on p. 147)



Dodge selects Enjay Butyl rubber for big rear-window weatherstrip

Super-durable Enjay Butyl fits perfectly Dodge's rigid specifications for its rear-window weatherstrip. Under the toughest conditions of weather and use, Enjay Butyl parts stay like new, help add style and color to new cars. In fact, some automobiles have more than 100 parts made of this fabulous rubber.

The many advantages of Enjay Butyl make it the almost perfect rubber for the automotive industry. Its price and ready availability are advantages, too. And it is now available in non-staining grades for *white* and *light-colored* parts. For full information and for skilled technical assistance in the uses of Enjay Butyl, contact the Enjay Company at either of the addresses below.

ENJAY
BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.
District Office: 11 South Portage Path, Akron 3, Ohio.

36 SUCCESSFUL YEARS OF LEADERSHIP IN SERVING INDUSTRY

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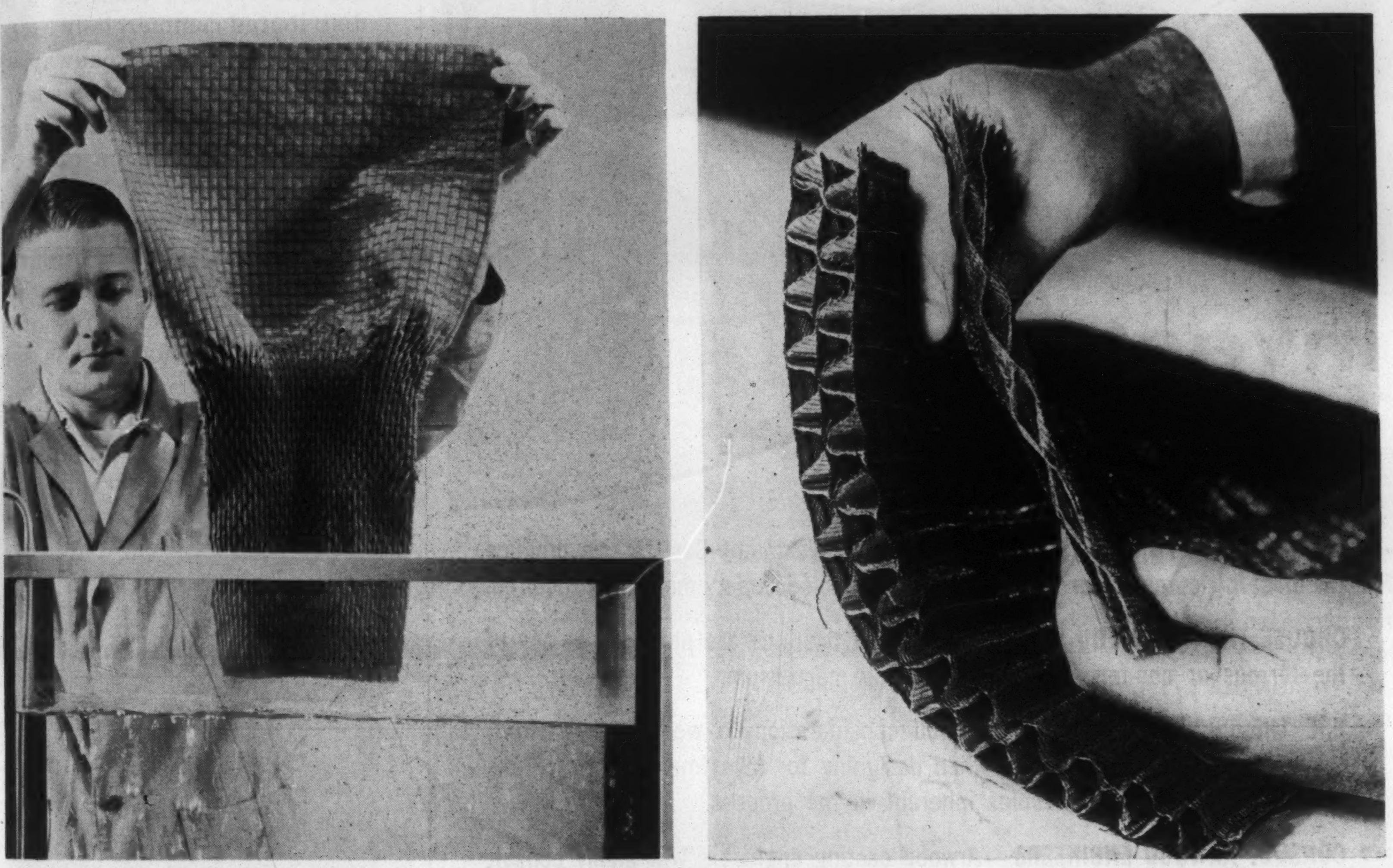
NEW MATERIALS PREVIEWS



Dipping the material *in boiling water shrinks pre-stretched polyethylene filaments giving puffed structure (right).*

Shrinking Polyethylene Provides 3-D Fabric

A three-dimensional fabric is now being produced using a unique combination of monofilament polyethylene and conventional yarns such as cotton, wool, silk, nylon and mohair. Prestretched polyethylene filament is woven into the fabric flat, on a conventional loom. The woven material is then dipped in boiling water which shrinks the plastics filament, puffing the fabric into patterns predetermined by the pattern of the weave. More complex patterns can be produced by weaving polyethylene in two directions in the fabric. The maximum 8 to 12% shrinkage of conventional yarns is negligible compared with that of polyethylene, which can range up to 55%.

Developed by *U. S. Rubber Co.*, 1230 Avenue of the Americas, New York, and called Trilok, the material is not totally compressible under a person's weight and will not collapse or flatten out under long periods of compression. In field tests as auto upholstery fabric, it has given wear equivalent to 15 years everyday usage. The material is resilient and contains enough stretch to simplify fitting seat contours. The fabric can also be molded by preheating which softens the polyethylene before fitting to the mold.

According to U. S. Rubber, Trilok's first use will be as an automotive and furniture upholstering fabric. The cushioning effect is said to offer comfort and allow free circulation of air between the seat and its occupant. It is also expected to find application as carpets and rugs, since undercushioning and carpet are combined in one fabric.

(Other New Materials, Products on p. 148)

design hints for investment casting

DESIGN PARTS FOR THE SHAPE YOU WANT—Investment Casting can produce the most intricately shaped parts with little or no secondary machining required.

CHOOSE THE ALLOY YOU WANT—Investment Castings are produced in any of the ferrous or non-ferrous alloys, including magnesium.

USE THE PROCESS WISELY—Give full consideration to weight, dimensions, tolerances and surface finishes when designing for Investment Casting. Take full advantage of the economies inherent in the process.

CONSULT ARWOOD ENGINEERS—Arwood casting engineers will gladly consult with you on your design and production problems, helping you translate them into finished products. Write for the name of your nearest ARWOOD sales and service representative.

DESIGN FLEXIBILITY

Parts similar to this stainless steel valve body for an air flow controller often require several changes before design is finalized. Due to the relatively low cost of dies and die changes, the investment casting process has proven an inexpensive and flexible method.

ARWOOD

ARWOOD PRECISION CASTING CORP.

74 Washington Street, Brooklyn 1, New York

Plants: Brooklyn, N. Y. • Groton, Conn • Tilton, N. H. • Los Angeles, Calif.

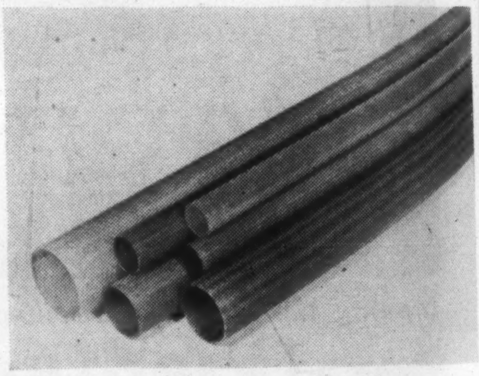
"PIONEERS IN INVESTMENT CASTING"

For more information, turn to Reader Service Card, Circle No. 495

OTHER NEW MATERIALS, PRODUCTS

Metallized Mylar Laminates

Mylar polyester film, vacuum metallized and laminated to various fabrics and plastics is being distributed commercially by *Dura-Grip, Inc.* 808 Broadway, New York 3. Called Chromeflex, the material is said to be impervious to water. It remains undamaged by chemicals, soaps, alkalies and solvents, and is tarnish proof and fade resistant. It has high dielectric and mechanical strengths and withstands temperatures of —75 to 300 F. The material is said to be particularly well suited for use in clothing and shoes, wall surfacing and upholstery, furniture and lamps and luggage and leather goods.

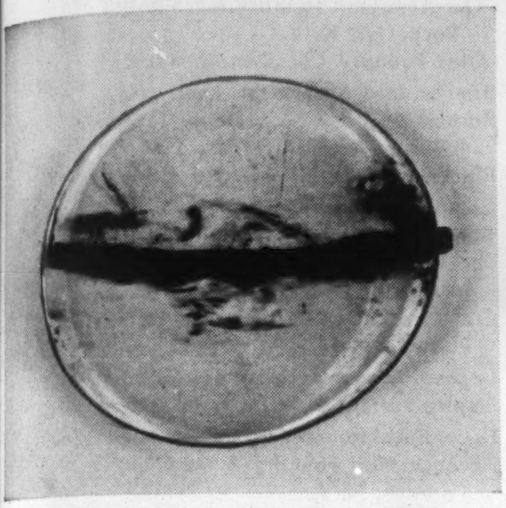


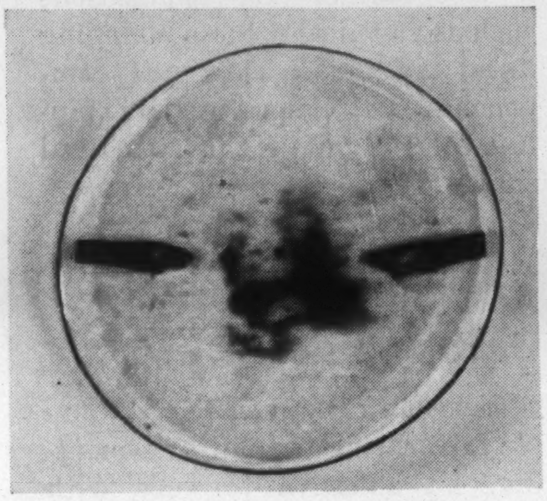
Epoxy-Glass Tubing

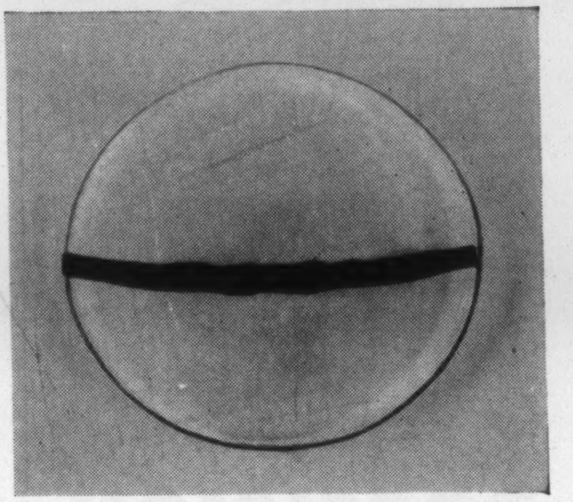
Glass fiber-reinforced epoxy resin tubing, manufactured by a method said to produce laminates with physical, chemical and electrical properties hitherto unavailable, is being marketed by *Lamtex Industries, Inc.*, 51 State St., Westbury, N. Y. The tubing is said to have a high degree of concentricity throughout length, to have high burst strength, to withstand temperatures up to 350 F and to have moisture absorption of less than 1% after 90 days of water immersion. Electrical insulation resistance of the impregnating resin is 1 x 10^{16} ohm-cm at 77 F and 1 x 10^{12} ohm-cm after 35 days at 95% relative humidity and 140 F. Tubing is produced in standard lengths up to 9 ft, in

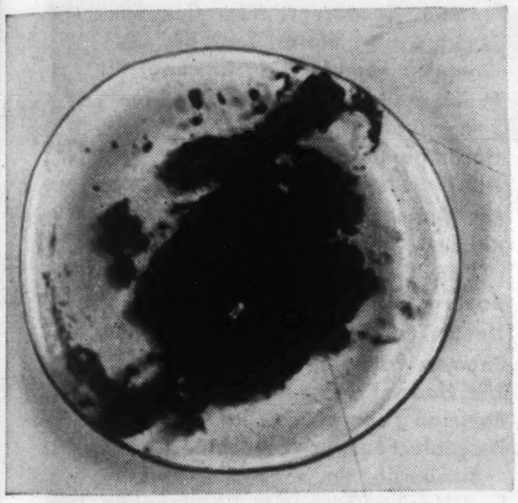
KEL-F® ELASTOMER IS SHATTERING IDEAS ABOUT RUBBER

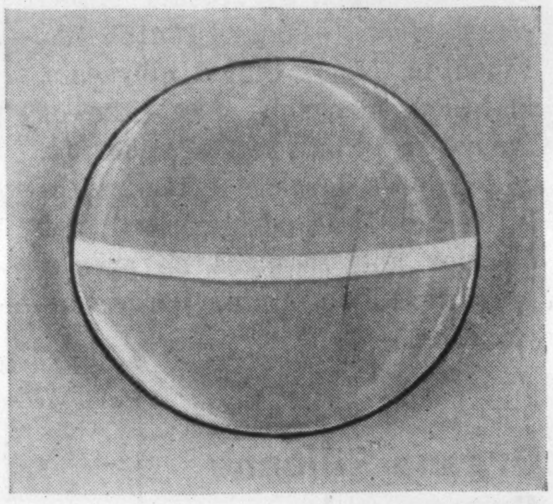
Challenging new fluorocarbon rubber has outstanding... CHEMICAL RESISTANCE... HEAT RESISTANCE


BUNA-N—10 min. immersion in RFNA


NATURAL RUBBER—10 min. immersion in RFNA


BUTYL—2 hr. immersion in RFNA


GRS—10 min. immersion in RFNA


KEL-F ELASTOMER—one week immersion in RFNA

IMMERSION IN RED FUMING NITRIC ACID for one week has no appreciable effect on the physical properties of KEL-F Elastomer. Extensibility and hardness remain virtually unchanged. Other available rubbers disintegrate within a matter of minutes.

When severe operating conditions demand a chemical rubber that *must* stand up under high temperatures and corrosive atmospheres—KEL-F Elastomer is the answer.

Developed by Kellogg, KEL-F fluorocarbon rubber combines superior elastomeric properties with excellent chemical resistance and thermal stability. Other outstanding advantages include: high chemical resistance to solvents, fuels and lubricants... low moisture absorption... non-flammability... excellent resistance to weathering and microorganisms.

This *unique* combination of properties makes KEL-F Elastomer useful in applications such as heat-and-chemical-resistant hose, tubing, diaphragms, gaskets, seals, tank linings, corrosion-resistant clothing, paints, flame-resistant coatings, and electrical insulation.

If your work requires an elastomer with outstanding resistance to heat and corrosion, look into KEL-F Elastomer. Our technical staff is prepared to assist designers, engineers, and production men in adapting KEL-F Elastomer to their individual needs. Kellogg supplies KEL-F Elastomer in the gum form only. Names of qualified fabricators of specific end uses of KEL-F Elastomer are available on request.

HOT OFF THE PRESS! *Our newly published booklet, "KEL-F Elastomer," is yours for the asking. Just fill out and mail coupon below for your free copy.*

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OTHER NEW MATERIALS, PRODUCTS

a range of diameters down to 1/16 i.d. Greater lengths can be supplied on order. The tubing was originally developed for electronic fuel gage probes for aircraft, but is also suitable for applications such as chemical process plumbing lines and tanks, electronic components, petroleum product piping, and light-weight structural shapes.

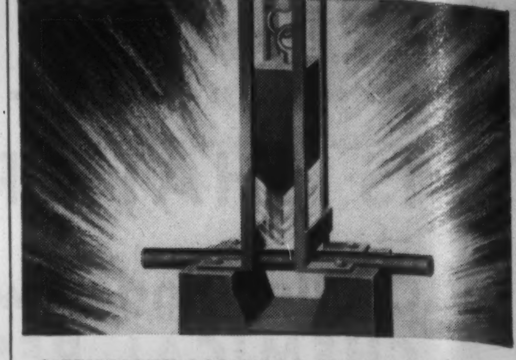
Adhesive for Urethane Foam

Especially designed to allow ample fabricating time after cementing, an adhesive for use with polyurethane foamed plastics has been developed by *Anchor Adhesives Corp.*, 36-23 164th St., Flushing, N. Y. Called Polyseam, it has a workable tack time of from 3 to 10 min after cementing, and it loses depression tack within 24 hr. It is odorless, will not discolor and requires no special preparation or mixing before application.

Organo-Silicone Compounds

Six organo-silicone compounds with unusual lubricating and solubility properties have been developed and are available in commercial as well as developmental quantities. They are expected to find broad use as special lubricants, as release agents for rubbers and plastics, in cosmetics, and as emulsifying agents or emulsion breakers. Developed by *Linde Air Products Co., Div. of Union Carbide and Carbon Corp.*, 30 E. 42nd St., New York 17, the compounds are designated X-520, X-521, X-522, X-525, X-526, and X-527. The latter three compounds correspond with the first three in composition except that the latter contain 0.5% oxidation inhibitor (phenyl alphanaphthylamine).

Like silicone oils, the materials



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The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington and Dover, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Farrel-Birmingham Co., Inc., Ansonia, Conn.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Shenango-Penn Mold Co., Dover, Ohio
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Sterns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
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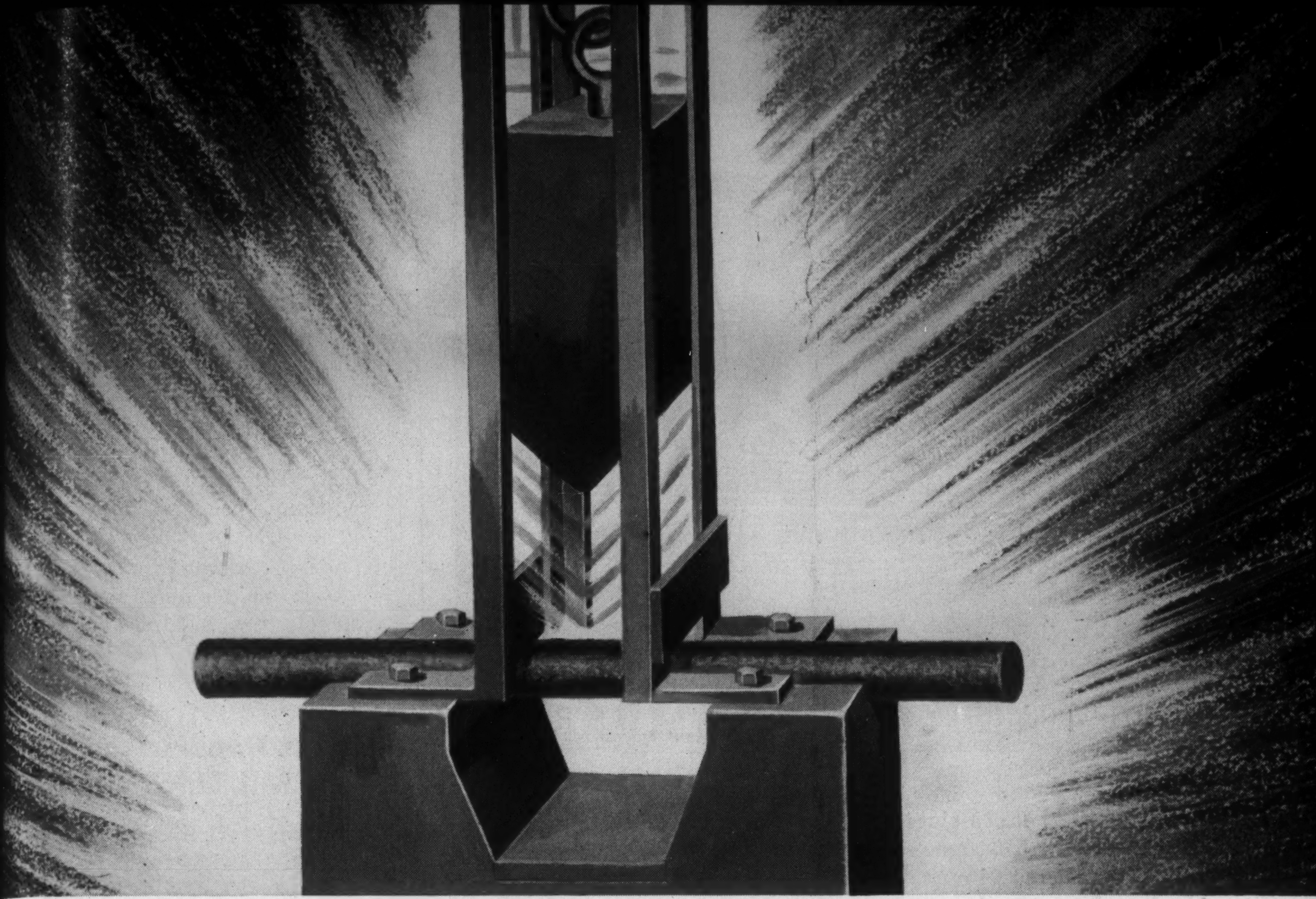
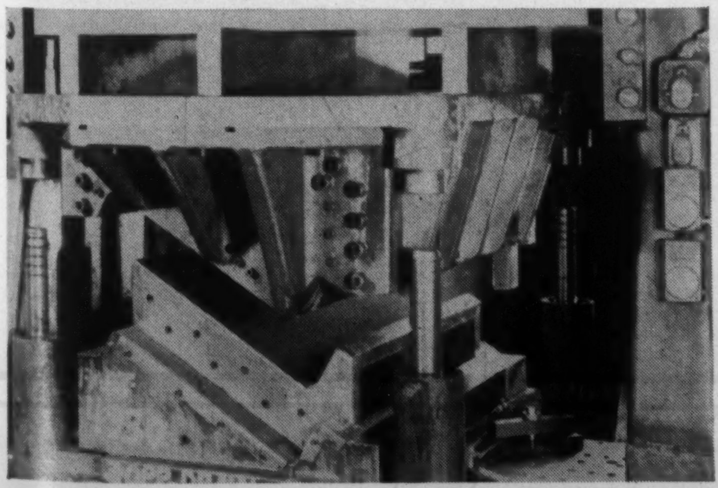


EXCELLENT SHOCK-RESISTING PROPERTIES OF MEEHANITE CASTINGS OFFER PROOF OF HIGH STRENGTH AND TOUGHNESS

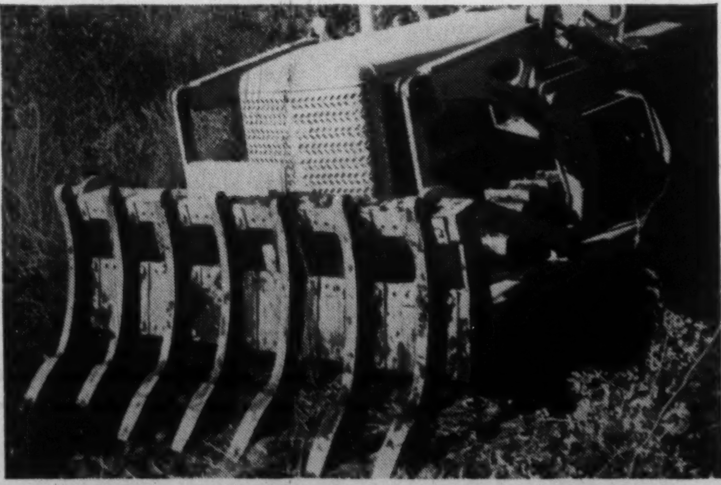
PERMANENT DISTORTION				
Impact Foot Pounds	Mild Steel: Deflection	Cast Steel: Deflection	Type GA Meehanite, As Cast: Deflection	Type GAH Meehanite, Heat-Treated: Deflection
10	0	0	.001	0
12½	.005	.005	.004	0
15	.007	.007	.008	0
17½	.024	.027	.013	0
20	.037	.047	.019	.002
22½	.048	.064	.027	.005
25	.071	.089	.033	.006
27½	.098	.110	.042	.007

These drop test results provide a measure of the impact strength of Meehanite. Test bars (1" dia. x 8" long) were subjected to a series of blows from different heights.

Structurally controlled Meehanite Metal Castings are available in 26 different property combinations to meet exacting engineering requirements. When superior shock-resistant qualities combined with strength and wear resistance are demanded, Meehanite Metal control provides designers and engineers with assurance of casting uniformity and dependable job performance. *For more information, send for your copy of the "Handbook of Meehanite Metals."*



Meehanite Forming Dies give longer service life and freedom from scuffing and galling.



Meehanite Metal Tooth Caps for heavy-duty land clearing rakes provide long wear life without failure under severe impact conditions.

MEEHANITE METAL®

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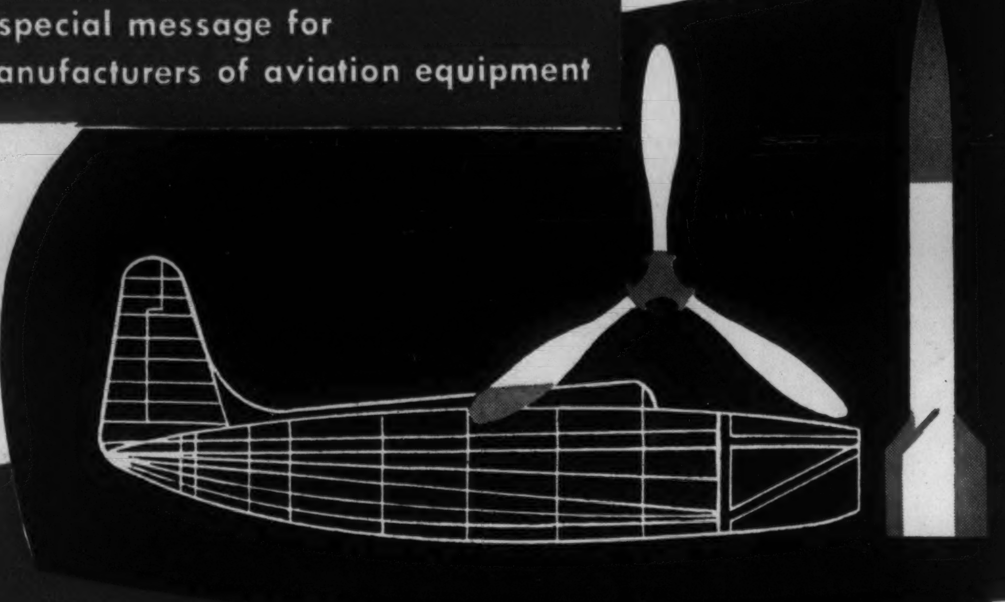

a special message for
manufacturers of aviation equipment

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Here's the finish that combines corrosion resistance and paint adherence with extreme ease of application. It can be welded or soldered with no difficulty and presents no problem in "patching" scratches, marks or scraped sections. Here's what you can do with Iridite:

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified phone book.

Iridite is approved under government specifications

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WEST COAST LICENSEE: L. H. Butcher Co.

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OTHER NEW MATERIALS, PRODUCTS

have excellent release properties, special thermal and viscosity stability and water repellency. In addition, they are said to have lubrication and anti-wear properties rivaling those of petroleum oils. They can also be used as emulsion breakers for oil products, or as emulsifying agents under other conditions. Four are water soluable and two are easily soluble in both high and low aromatic solvents.

Glass Paper One Mil Thick

A new one-mil thick paper made of glass micro-fibers is expected to find many applications in both the electrical and plastics industries. The paper combines mechanical strength with high absorbency, according to the producers, *L.O.F. Glass Fibers Co.*, 1810 Madison Ave., Toledo 1, Ohio. The glass micro-fibers are highly inert and do not break down under adverse conditions. They are 100% inorganic and contain no metallic impurities, giving them high insulating efficiency. The paper impregnates readily with silicones, electrical varnishes and plastics resins. It is uniformly one-mil thick, though other thicknesses are available, and it meets all requirements for Class H insulation.

Class C Insulation in Sheet Form

A completely inorganic Class C insulating material consisting of flake mica and a mineral binder is said to have a heat distortion point of 1700 F. It is flame resistant, arc resistant with no carbon tracking, and has excellent dielectric strength and workability. It is being produced by *Spruce Pine Mica Co.*, Spruce Pine, N. C., under the trade name Micaramic. The material can be punched and

New Du Pont MYLAR
REG. U. S. PAT. OFF.
# adds improved qualities to pressure-sensitive tape

Pressure-sensitive tapes made with new Du Pont "Mylar"* polyester film are giving superior performance in a wide variety of diversified industrial uses. That's because tapes made with "Mylar" offer long-lasting strength in conjunction with chemical resistance, dielectric strength, and thermal stability.

Whether it's masking for electroplating or harness-wrapping coils, pressure-sensitive tapes made with new Du Pont "Mylar" increase efficiency, improve performance and, in the case of electrical applications, help decrease weight and size of the finished product.

Du Pont manufactures only the base material, "Mylar." The various firms that make pressure-sensitive tapes using "Mylar" offer a variety of gauges, widths, and types of adhesives. Send in coupon below for names of manufacturers and the new booklet listing properties and applications of pressure-sensitive tapes made with "Mylar."

Thin, yet strong . . . gives a snug wrap over irregular, bulky surfaces.

Amazing dielectric strength, thermal stability, for countless electric uses.

Dimensionally stable, can be used over a wide range of temperatures.

Can be metalized, printed, used for coding pipes and wires . . . decorative effects.

Resists edge fraying, has great tear strength... is ideal for tough jobs.

Resists effects of corrosion and moisture over wide range of temperature and humidity.

**Registered Du Pont trademark for its brand of polyester film*

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. . . THROUGH CHEMISTRY

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POLYESTER FILM

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☐ Please send me your new booklet on pressure-sensitive tapes made with "Mylar" and names of manufacturers.

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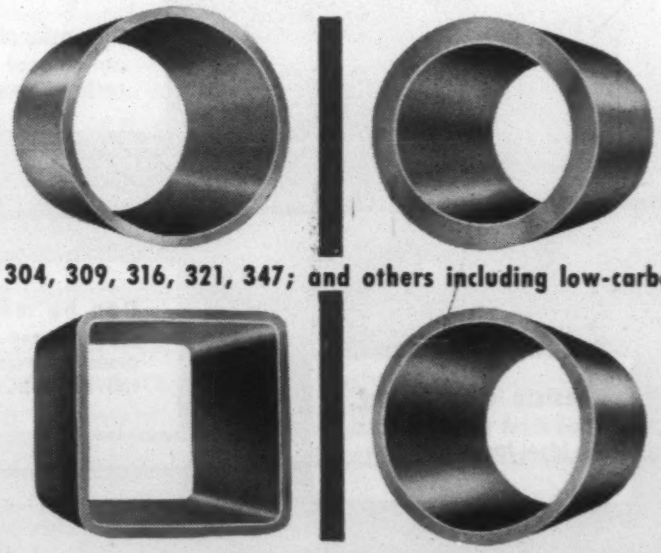

TUBE SIZES:
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.025 to .148

PIPE SIZES:
⅛″ to 2″ IPS
Schedule 40

TYPES: 430, 302, 304, 309, 316, 321, 347; and others including low-carbon grades.

SHAPES:
Squares,
Rectangles
and
Special
Shapes

PIPE SIZES:
⅛″ to 4″ IPS
Schedules
5 & 10

Send for Stainless Folder! Our engineers will gladly assist you in your selection of the tube best suited to your needs! Write today!

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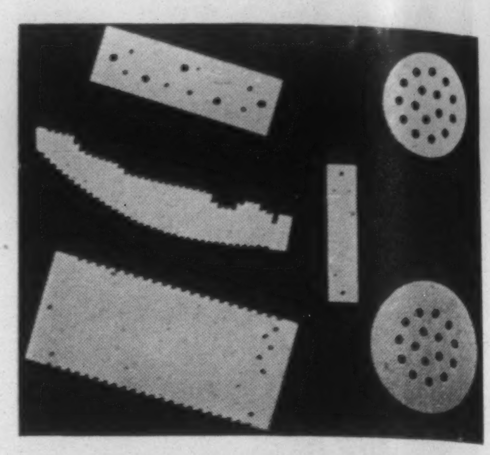
OTHER NEW MATERIALS, PRODUCTS



shaped as well as extruded. Thin sheets are available in thicknesses of 20 mils to ½ in. The material can also be furnished with Teflon or silicone impregnates. It has been used in appliances, controls, industrial heaters and foundry strainer cores. It is presently being evaluated for use in printed circuit applications.

Low Toxicity Epoxy System

An epoxy laminating resin and a surface coat resin have been formulated to reduce or eliminate toxic effects in use. Developed by *Marblette Corp.*, 37-21 Thirtieth St., Long Island City 1, N. Y., the materials, when blended with Marblette's No. 20 accelerator for room temperature setting, are said to minimize possibility of allergic reactions in susceptible workers.

Laminating resin No. 607 has a long storage life and provides high fiber laminating bond strength. It has low viscosity and thoroughly wets fibrous glass reinforcing materials. It provides laminates with good chemical resistance, low shrinkage and high dimensional stability.

Surface coat resin No. 604 is a heavy-consistency liquid that spreads evenly and will not run off vertical surfaces. It is designed for use as a gel coat on molds and models, particularly where it is desirable to hide the texture of the glass reinforcement.

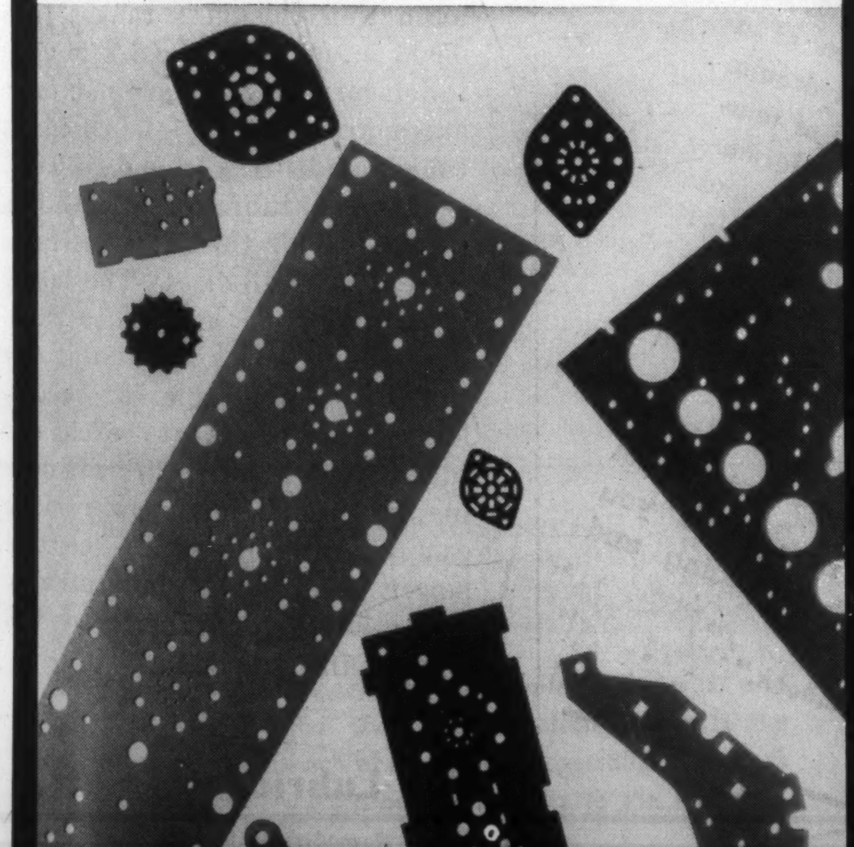
(More New Materials on p. 156)

Textolite®

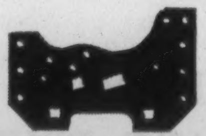
LOW COST—HOT OR COLD

Punching Grade Laminates

DESIGNED FOR AUTOMATIC PRODUCTION



CONSISTENTLY EQUALS OR EXCEEDS NEMA STANDARDS



G-E TEXTOLITE punching grade laminates have been designed to provide low-cost hot or cold punching laminates with excellent electrical and mechanical properties, geared to meet the requirements of today's high-speed production techniques.

These hot or cold punching grade laminates, engineered by General Electric, have been developed to meet the varied requirements of electrical and electronics manufacturers. Among the wide selections available are:

TEXTOLITE HOT PUNCH 2053 — High mechanical strength and electrical properties at low cost.

TEXTOLITE COLD PUNCH 11561 — Can be cold punched to ⅛" thick. Has good mechanical strength.

TEXTOLITE 11562 — Warm punch grade with a good combination of mechanical strength and electrical properties. NEMA grade P.

TEXTOLITE 11563 — Hot punch grade with stable electrical properties under humidity conditions. NEMA grade XXP.

TEXTOLITE 11564 — Best electronic insulation grade for high dielectric strength, low cold flow, and best humidity resistance. Hot punching NEMA grade XXXP.

These standard industrial grade laminates have a uniform color and appearance, and offer a new ease of fabrication. They CONSISTENTLY exceed NEMA values.

All TEXTOLITE punching grade laminates are available with copper foil on one or both surfaces, in flat sheets, for printed circuitry.

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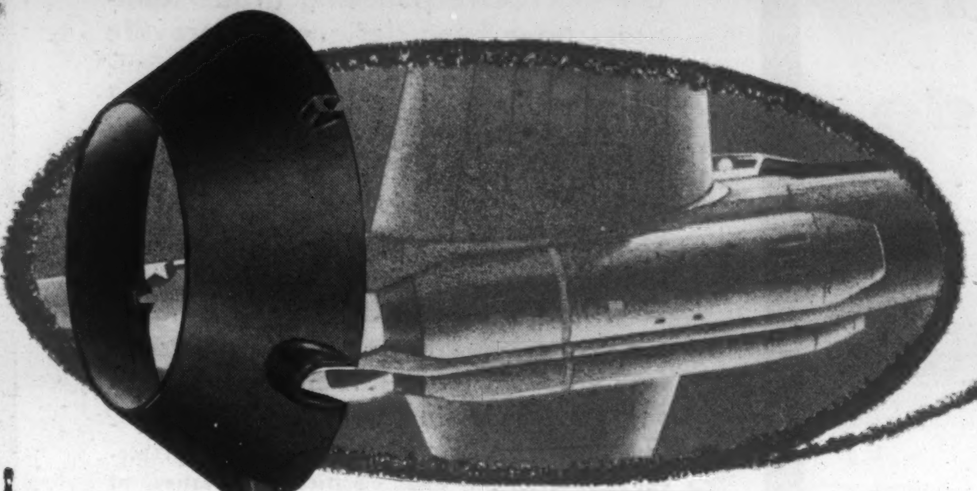
THE SHAPE OF THINGS IN MOLDED SILICONE

SILI-CONE PROVES REAL COOL
FOR JET AIRCRAFT EQUIPMENT



APPLICATION:
Thermal barrier for jet aircraft accessories.

PROBLEM:
The original part, along with drawings and molds, was presented to Acushnet by a well-known manufacturer of accessories for conventional and jet aircraft with orders to continue development with Dow-Corning 301 compound. The idea was to attain a part that would provide maximum physical properties at elevated temperatures of over 800°F.

SOLUTION:
Overcoming the high bulk factor of the compound was accomplished through the design and construction of a preform. Running the original mold in a special hydraulic ram equipped with controls permitting a wide range of temperatures and pressures, provided the necessary information in curing this compound. The resultant cure times and pressures enabled Acushnet engineers to design and construct a compression mold of hardened steel that made this part possible. Included in this project were small gaskets molded from Dow-Corning 301 that proved superior to metal in high heat insulating applications.

Pioneers in the advanced mold techniques and custom compounding of silicones, Acushnet now offers you immediate technical assistance in the molding and finishing of silicone resins.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS
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Address all communications to 750 Belleville Ave., New Bedford, Mass.

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OTHER NEW MATERIALS, PRODUCTS

Paste Seals Polyester Structures

A wipe-on paste is being marketed by *Furane Plastics, Inc.*, 4516 Brazil St., Los Angeles 39, for sealing low-pressure laminated polyester structures. Designated Epocast H-991-A, the material is said to seal pin holes to provide smooth, uniform surfaces. The material is packaged in pint, quart and gallon kits with suitable amounts of hardener.

Larger Light-Wall Stainless Tubing

Production limits for light-wall stainless steel tubing produced by welding and cold drawing have been expanded from 1⅛ to 2-1/16 in. o.d. by *Superior Tube Co.*, 1548 Germantown Ave., Norristown, Pa. The tubing is available in types 304, 321, and 347 stainless steels and in monel. Minimum wall thickness ranges from 0.006 in. on smaller o.d.'s to 0.010 in. on larger. Standard o.d. tolerances are +0.005, −0.000 in. on tubing under 1½ in. o.d., +0.010, −0.000 on tubing 1½ to 2-1/16 in. o.d. Wall thickness tolerance is ±10% on all sizes. The tubing is furnished in lengths to 28 ft.

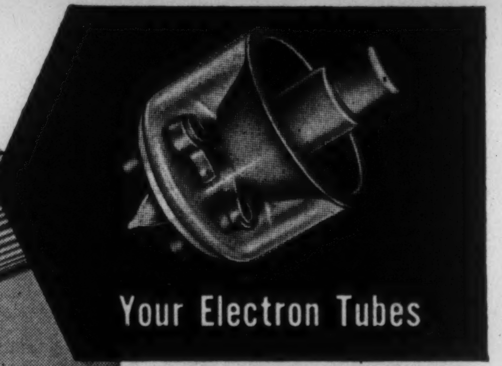
The new sizes of tubing are said to be applicable for bellows, low pressure heat exchanger tubes, flexible hose, aircraft ducting, fractional horsepower motor casings, ceramic drills, electron power tube anodes and cathodes, and casings for radioactive well logging instruments.

Dry Lubricant

A dry lubricant consisting of concentrated molybdenum disulfide is said to be particularly effective when used for break-in running, wire drawing, tools, dies, threaded parts and other difficult-to-lubricate areas. Called Molyfilm, the fine gray powder when

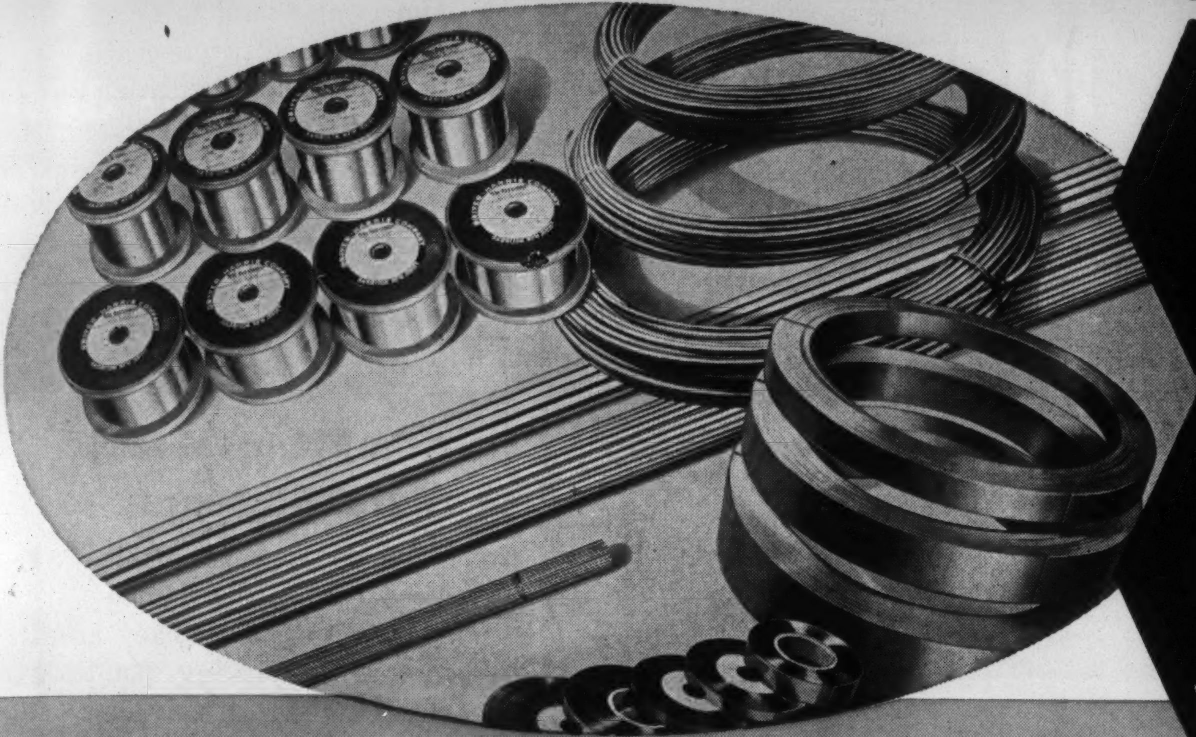
These DRIVER-HARRIS alloys do most to improve the quality of

Your Resistors



Your Electron Tubes

Your Glass-to-metal Seals



DRIVER-HARRIS RESISTANCE WIRE ALLOYS

NICHROME* V (Nickel-Chrome) Essential for resistor elements in the higher temperature applications such as electric furnaces, electric ranges, radiant heaters, etc.

KARMA* (Nickel-Chrome-Aluminum-Iron) Permits the manufacture of miniaturized wire wound precision resistors of best temperature coefficient of resistance at low cost per ohm; also resistance standards.

NICHROME* (Nickel-Chrome-Iron) The internationally accepted material for heating devices operating up to 1700°; also industrial applications for rheostats and resistance units.

CHROMAX* (Nickel-Chrome-Iron) A lower cost alloy for electrical heating under conditions less critical than those satisfied by Nichrome.

ADVANCE* (Copper-Nickel Series including MIDOHM*, 95 ALLOY, LOHM*, 30 ALLOY) Possess a number of properties which make them useful for winding heavy duty industrial rheostats, precision resistors, thermocouples, and thermocouple leads. Specific resistance range of this series is from 294 to 30 ohms/cmf.

MANGANIN (Manganese Copper) Most stable resistance wire known at ambient temperature. Indispensable for resistors used in many types of precision direct current apparatus such as Wheatstone Bridges, National Bureau of Standards type resistance standards, etc.

HYTEMCO* (Nickel-Iron) Combines high temperature coefficient of resistance with high specific resistance; ideal for winding compensating or ballast resistors.

DRIVER-HARRIS GLASS SEALING ALLOYS

THERLO* (Nickel-Cobalt-Iron). For sealing glasses such as Corning 7052 and 7040.

142 ALLOY (Nickel-Iron). For sealing glasses such as Corning 776, also 8160.

52 ALLOY Contains 50% nickel. It provides a slightly higher coefficient of expansion than 142 Alloy and seals successfully with 0120 glass.

146 ALLOY Contains 46% nickel. It offers special expansion properties, permits seals with ceramic coated resistors.

DRIVER-HARRIS ELECTRON TUBE ALLOYS

The Driver-Harris Company, since the inception of radio, has been making alloys for this field, supplying the industry with alloys for support wires, plates, grids, cathodes, and lead-throughs.

All Alloys are available in:

WIRE
(Sizes as fine as .0005)
ROD
RIBBON
STRIP
(Foil as thin as .00045)

Insulations:

ENAMEL
COTTON
SILK
NYLON
GLASS
FORMVAR

Singly or in combination

Every Driver-Harris alloy is made to the most precise metallurgical checks and controls known to the industry. And each of these highly specialized alloys is custom-made . . . produced exactly to the specifications of our customers.

Send us *your* specifications. If your needs are in any way unusual, and cannot be met by one of our current 112 alloys, our engineers will be happy to start tomorrow to devise a new one, custom-made for you. Just tell us exactly what you wish to accomplish.

*T.M. Reg. U.S. Pat. Off.

Nichrome
and Nichrome V
are made
only by

SPECIAL PURPOSE ALLOYS SINCE 1899
D/H
TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris Company HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco

In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

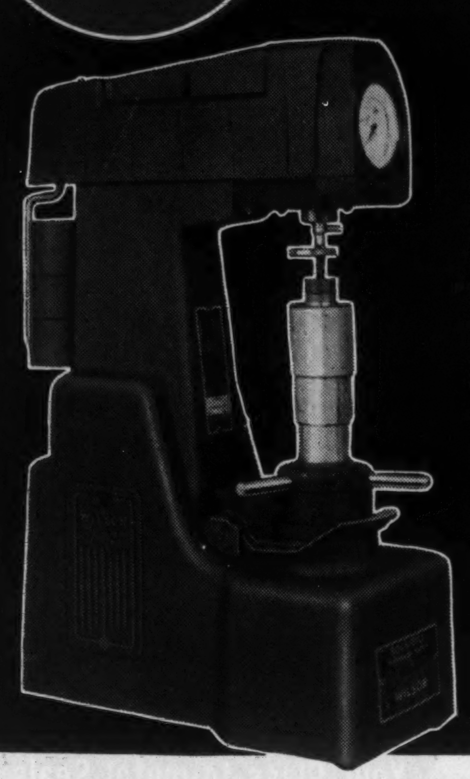
MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

For more information, turn to Reader Service Card, Circle No. 366

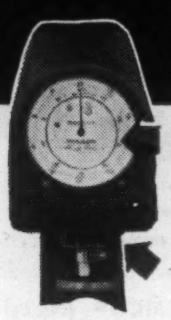
an ACCO product

Wilson "Rockwell"* Hardness Testers

Tests with INCREASED SPEED... Accurately



Y Model Motorized Hardness Tester



Requires fewer operating steps... *Because*

IT'S MOTORIZED

• Here is the motorized operating procedure made possible by the new WILSON "Rockwell" Y Model Motorized Hardness Tester—

1 Place specimen upon anvil or table.

2 Elevate test piece into test position. (With the new Set-O-Matic Dial Gauge, the large pointer will then automatically point to zero.)

3 Tap depressor bar to apply Major Load. When Major Load is fully applied, the Motorized Mechanism takes over—completes the test cycle—removes the Major Load.

4 Read "Rockwell" Hardness Number. Then, lower elevating screw to remove test piece.

For complete information about the WILSON Y Model, or any others of the complete line of WILSON "Rockwell" Hardness Testers, write or call today. A WILSON hardness testing expert is available to consult on your specific requirement.

Trade mark registered

Illuminated Dial Gauge

(1) Affords clear and easy reading. Readings are easily taken wherever your "Rockwell" Tester is located—whatever the lighting conditions of the room.

Indenter light (2) is directed towards the test area, making it easy to locate the exact area of test at all times.

Set-O-Matic Dial Gauge

The Set-O-Matic Dial Gauge increases the accuracy of the test, makes the test cycle shorter and increases the number of readings obtainable within a definite period of time.

ACCO

Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-E Park Avenue, New York 17, N. Y.

for Better Value

For more information, turn to Reader Service Card, Circle No. 349

OTHER NEW MATERIALS, PRODUCTS

applied to a surface is said to prevent galling, seizing and abrasion, and to reduce friction. Molyfilm is also said to be effective as a lubrication prime coating, forming the base lubrication on parts normally oiled and greased. Molyfilm is first allowed to work into the metal before oil and grease are applied. Temperatures up to 700 F are said to have no effect on Molyfilm coatings.

Non-Flammable Metal Cleaners

Three non-flammable cleaners were recently announced for cleaning metals. They are: 1) a line of fast drying, non-toxic cold cleaners; 2) a non-toxic, water-soluble liquid cleaner for removing buffing compounds; and 3) an emulsion cleaner for removing oily soils and greases.

Line of cold cleaners

The so-called Manpro Cold Cleaners are said to be fast drying, non-toxic, non-flammable and suitable for a variety of metal cleaning applications. They are produced by *Manufacturers Processing Co.*, 1360 Hilton Rd., Detroit 20. Cleaner No. 20 is said to be suitable for machinery wash-down, particularly electrical items since the cleaner is said to be a non-conductor. Cleaner No. 21 has no flash or firepoint. Cleaner No. 22 has low volatility and low dermatitis incident. Cleaner No. 23 is said to be particularly well suited for cleaning and degreasing electrical components in closed circuits. Cleaner No. 24 is said to offer maximum solvency and unusually safe limits of flammability making it particularly well suited for use in flushing, cleaning, and drying freon and gas refrigeration systems.

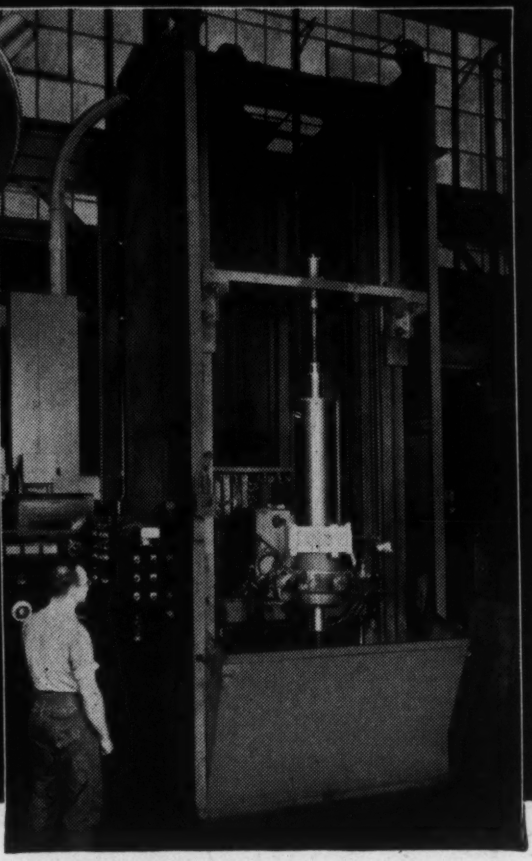
Water-soluble cleaner

A water-soluble liquid cleaner designed for removing all types of buffing compounds from ferrous and nonferrous metals has

Former Heat-Treating Time—28¼ HOURS
TOCCO Heat-Treating Time—30 MINUTES

Plus

$108 saved on every mill roll



This special mill roll hardening fixture is powered by two 200 KW, 3000 cycle TOCCO machines. Mill roll shown is 12" diameter by approx. 60" long.

with TOCCO* Induction Heating

When progressive engineers at The McKay Machine Company switched from conventional heat-treating methods to TOCCO induction hardening of their mill rolls, they achieved not only increased production but also important cost savings, and perhaps most important of all, a greatly improved product.

56 Times as Fast!

Formerly mill rolls required a 12-hour heat, a 15-minute salt brine quench, 12 hours tempering and a 4-hour cooling period. With TOCCO the whole job is done—and done better—in just 30 minutes—56 times as fast!

Here's Real Economy

Reduced furnace time saves $28.00 per roll. More important, grinding time is cut in half (saving $80 per roll) because TOCCO minimizes distortion and there's less stock that must be removed. Runoff used to be as much as ¼"—frequently requiring a separate straightening operation.

Product Improved

Because TOCCO "scans" the mill roll, i.e. heat treats it progressively, only a small section is at critical temperature at any one time. That's why distortion is minimized and little finish grinding is required. This means that TOCCO-hardened mill rolls have a *more uniform case-hardened depth* than possible with old fashioned methods which in turn means longer life and better performance.

• • •

Why not have a TOCCO engineer survey your plant to determine where TOCCO can reduce your costs, increase production speed and improve product quality?

THE OHIO CRANKSHAFT COMPANY

TOCCO

JUST PUSH A BUTTON

*Trade Mark Reg. U. S. Pat. Off.

Mail Coupon Today

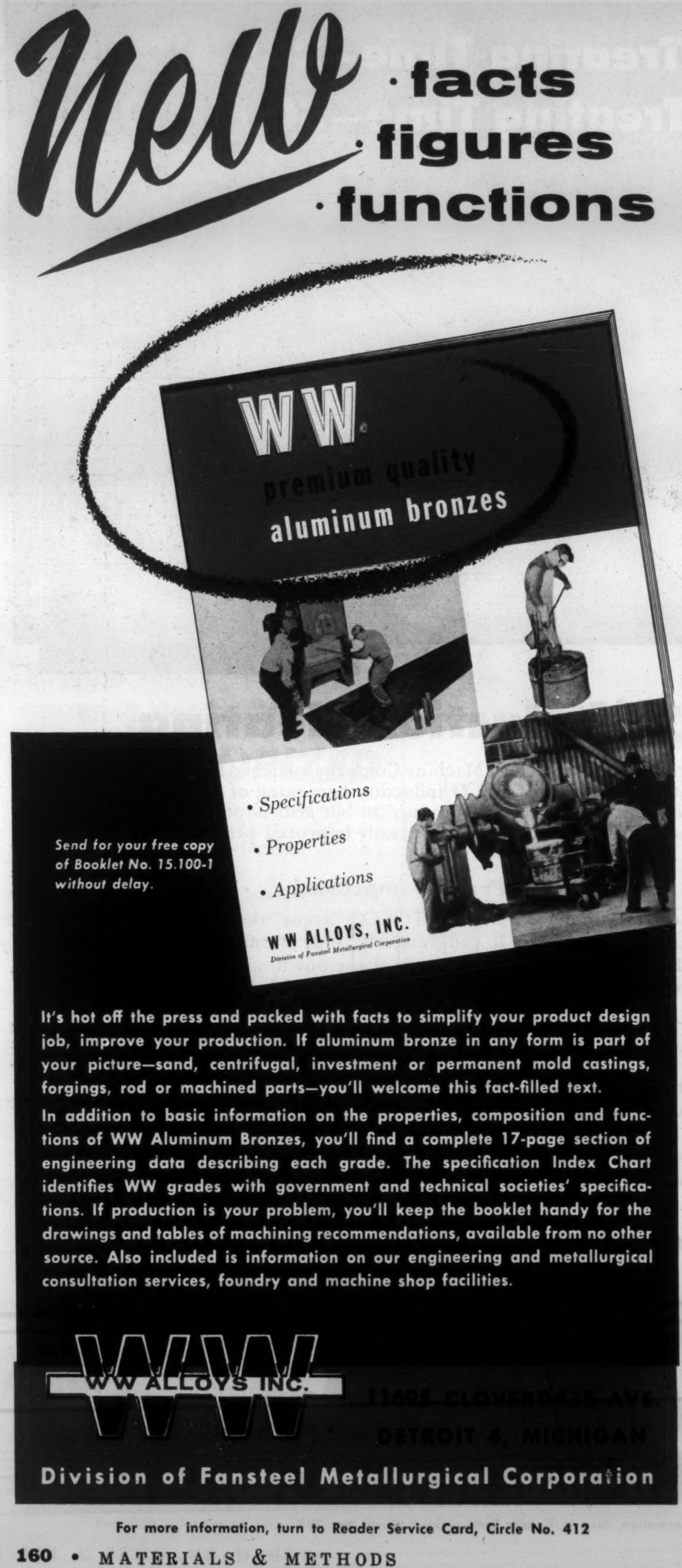
NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. T-2, Cleveland 5, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

Name________________
Position________________
Company________________
Address________________
City________ Zone____ State______

For more information, turn to Reader Service Card, Circle No. 388


New · facts · figures · functions

WW premium quality aluminum bronzes

- Specifications
- Properties
- Applications

W W ALLOYS, INC.
Division of Fansteel Metallurgical Corporation

Send for your free copy of Booklet No. 15.100-1 without delay.

It's hot off the press and packed with facts to simplify your product design job, improve your production. If aluminum bronze in any form is part of your picture—sand, centrifugal, investment or permanent mold castings, forgings, rod or machined parts—you'll welcome this fact-filled text.

In addition to basic information on the properties, composition and functions of WW Aluminum Bronzes, you'll find a complete 17-page section of engineering data describing each grade. The specification Index Chart identifies WW grades with government and technical societies' specifications. If production is your problem, you'll keep the booklet handy for the drawings and tables of machining recommendations, available from no other source. Also included is information on our engineering and metallurgical consultation services, foundry and machine shop facilities.

WW ALLOYS INC.
11695 CLOVERDALE AVE.
DETROIT 4, MICHIGAN
Division of Fansteel Metallurgical Corporation

For more information, turn to Reader Service Card, Circle No. 412

been marketed by *Cowles Chemical Co.,* 7016 Euclid Ave., Cleveland 3, Ohio. Called New Lixol, the material is mildly alkaline, but is neither a conventional alkaline cleaner nor a conventional solvent. It is non-toxic and nonflammable. Tank make-up calls for 2 gal of Lixol in 98 gal of water. Working temperature is 170 F, minimum immersion time is usually three minutes.

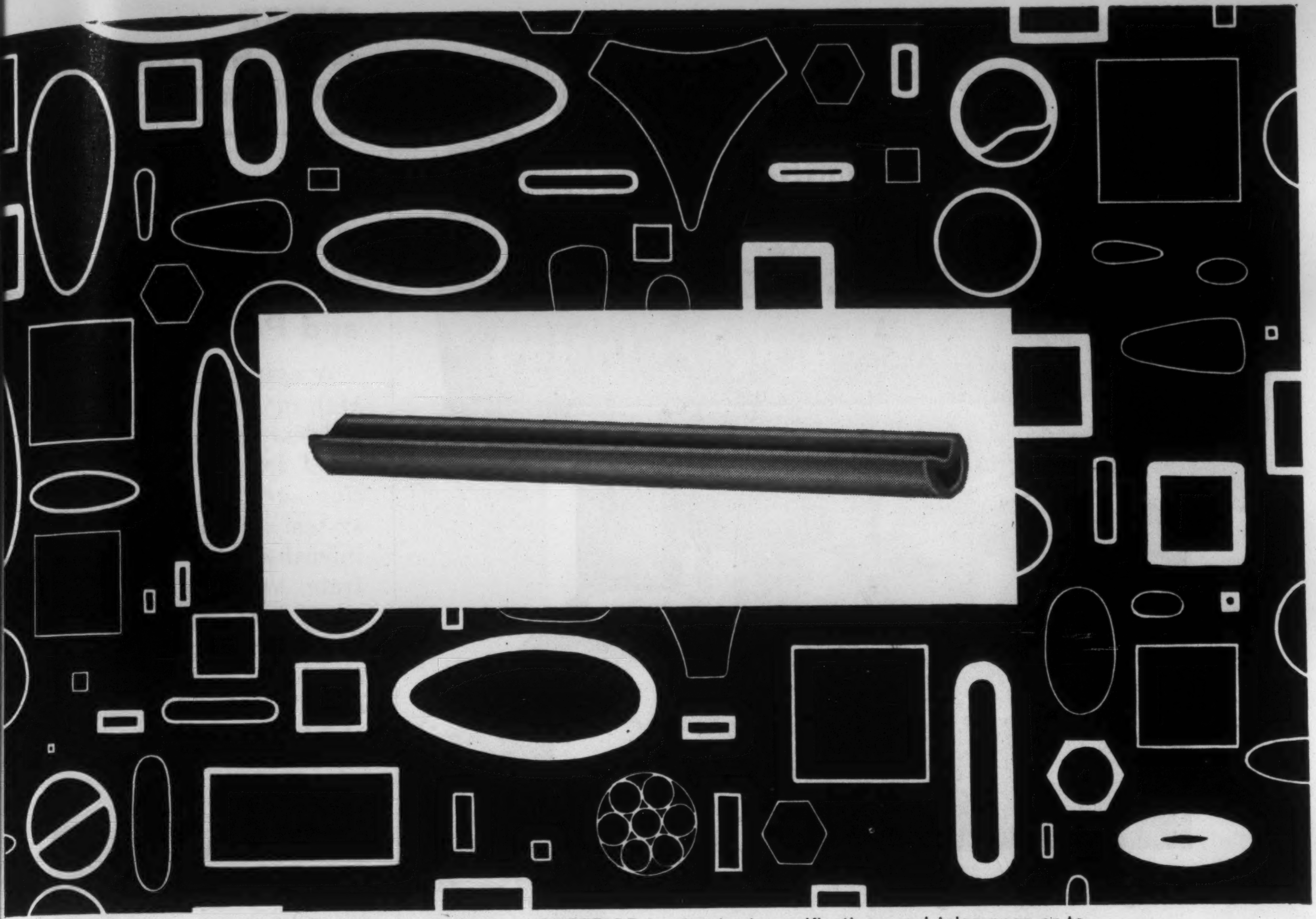
Emulsion cleaner

An emulsion cleaner for removing oily soil and greases from aircraft, ship bunkers, trucks, automotive and railroad equipment and heavy machinery has been marketed by *Kelite Corp.,* 1250 N. Main St., Los Angeles 12. Called Ke-Sonic, the material is said to be particularly useful for marine use because removed soil is held in a stabilized emulsion even when mixed with sea water. Ke-Sonic-C is used by diluting with kerosene, diesel fuel or No. 2 fuel oil, and applied to soiled parts by spraying, brushing, wiping or immersion. It is corrosion safe on all structural metals. Ke-Sonic may be diluted with up to 20 parts of water and used in industrial pressure washing machines. Both Ke-Sonic and Ke-Sonic-C are said to be fire safe, exhibiting a Cleveland open cup flash point of 180 F, and a Cleveland open cup fire point of 220 F.

Brazing Flux for Chromium and Nickel Alloys

A high temperature brazing flux for brazing chromium and nickel alloys has been developed by *Air Reduction Sales Co., Div. of Air Reduction Co., Inc.,* 60 E. 42nd St., New York 17. It is free-flowing and active in a temperature range of 1400 to 2000 F. It is designed for use on stainless steel assemblies used in jet aircraft, automotive, pharmaceutical and nuclear energy industries.

(More New Materials on p. 162)



A few of the shapes available from SUPERIOR in standard specifications and tolerances or to your own design. The tube in the foreground is a gun drill shank made from 4130 alloy steel.

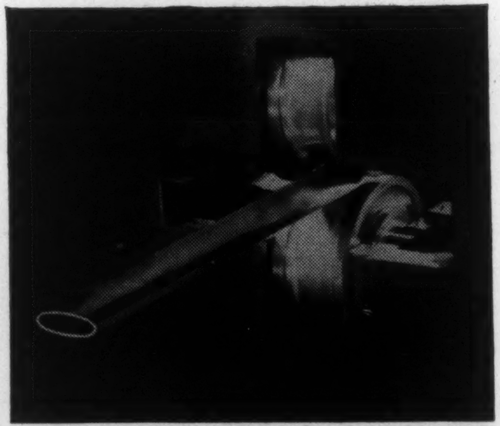
Save time and money on special shaped tubing

"SUPERIOR" TUBING IS IMMEDIATELY AVAILABLE IN A WIDE RANGE OF SHAPES, FORMS, ALLOYS

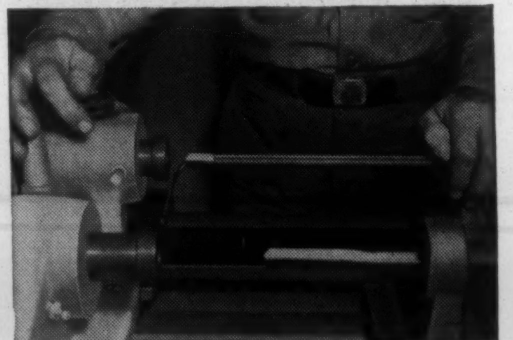
Many manufacturers have discovered that SUPERIOR's ability to supply as standard what many firms consider specialty tubing saves them trouble, time and money. SUPERIOR makes round, square, oval, rectangular, elliptical and flat oval tubing, for instance. It makes capillary tubing, pointer tubing, electronic tubing, telescopic sizes, large OD-light wall tubing. Over 55 analyses are available in carbon, alloy and stainless steels; in nickel and nickel alloys; in beryllium copper, titanium, zirconium.

The gun drill shank shown above and on the right is a good example of SUPERIOR's ability to supply unusual shapes. This newly rediscovered method of producing close-tolerance high-finish holes demands straight, rigid, accurate shanks with a 110° V-groove. SUPERIOR can produce such a shape—and others—in a fraction of the time and cost it would take a customer to form his own.

If you're having difficulty getting the kind of tubing you want, SUPERIOR can undoubtedly help you. Write for your free copy of Bulletin 40—*A Guide to the Selection and Application of Superior Tubing*. SUPERIOR TUBE COMPANY, 2006 Germantown Ave., Norristown, Pa. *On the West Coast:* Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif.



Turks-head rollers converting a round section of SUPERIOR tubing into the typical elliptical shape for a Bourdon gage tube.



Gun drills can produce holes from 4 to 230 diameters or more in 4 times the speed of conventional drilling methods or better. Holes so produced are straight and round to tolerances of 0.0002" or less and wall finishes are 7 mu-in or better.

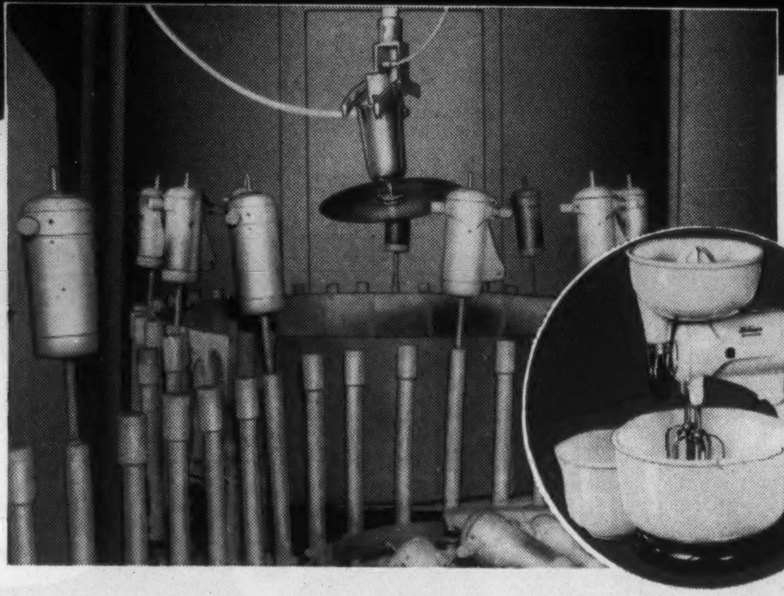
All analyses available in .010" to ⅝" OD; certain analyses in light walls up to 2½" OD

Superior Tube

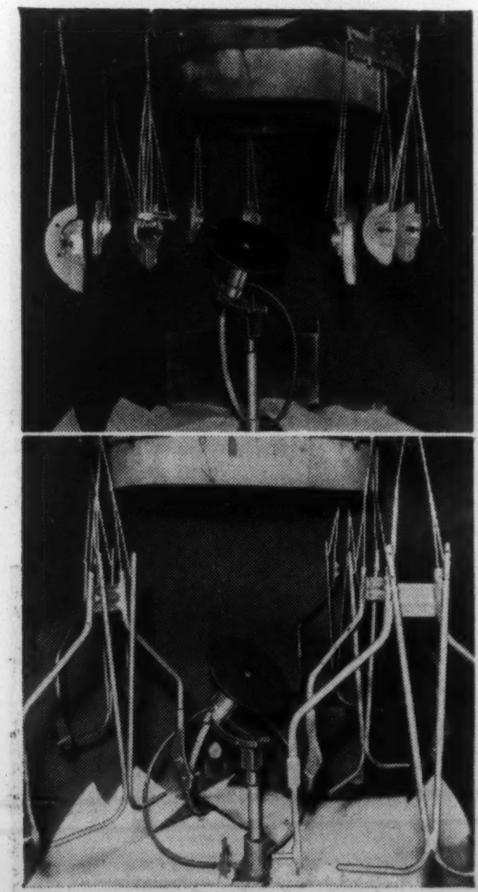
The big name in small tubing

For more information, turn to Reader Service Card, Circle No. 339

Sunbeam is particular about the uniform high quality finish on their products, so SUNBEAM relies on RANSBURG NO. 2 PROCESS Electrostatic Spray Painting



Along with improving the quality of the brilliant white finish on Mixmaster parts, an 80% paint savings was achieved when SUNBEAM switched from hand spray to RANSBURG Electrostatic Spray Painting



Protective clear lacquer is applied to upper saw guard (upper left) with RANSBURG NO. 2 PROCESS on this line in SUNBEAM's plant 2, Chicago. Other hardware items, including the Drillmaster and Sunbeam Sander are lacquer-coated electrostatically here. Lawn mower parts, such as the handles shown (lower left), the Rain King lawn sprinkler base, and the Sunbeam Fryer base also are painted efficiently with Ransburg No. 2 Process Electro-Spray.

Regardless of the type of product you manufacture, if it's painted—and if your production justifies conveyorized painting—you should look into the savings and improved quality which can be yours with one of the Ransburg Electrostatic Processes. May we tell you about complete Ransburg services, including the test painting of your products in our laboratories?

Write to Dept. M.

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

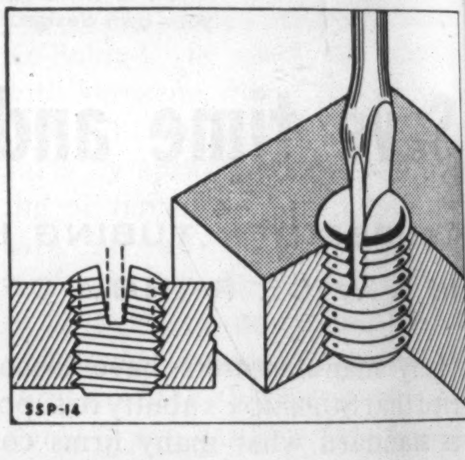
For more information, turn to Reader Service Card, Circle No. 510

OTHER NEW MATERIALS, PRODUCTS

Coloring Systems for Polystyrene and Polyethylene

A system of dry colorants for high impact polystyrene and polyethylene is based on a pre-lubricated formula requiring no wetting agents. Called Colortrol, the system is said to provide a more intensive type of color concentrate, resulting in greater uniformity of dispersion and truer fidelity in exactness of color match. It is produced by *Riverdale Color Co., Inc.*, 425 South St., Newark 5, N. J.

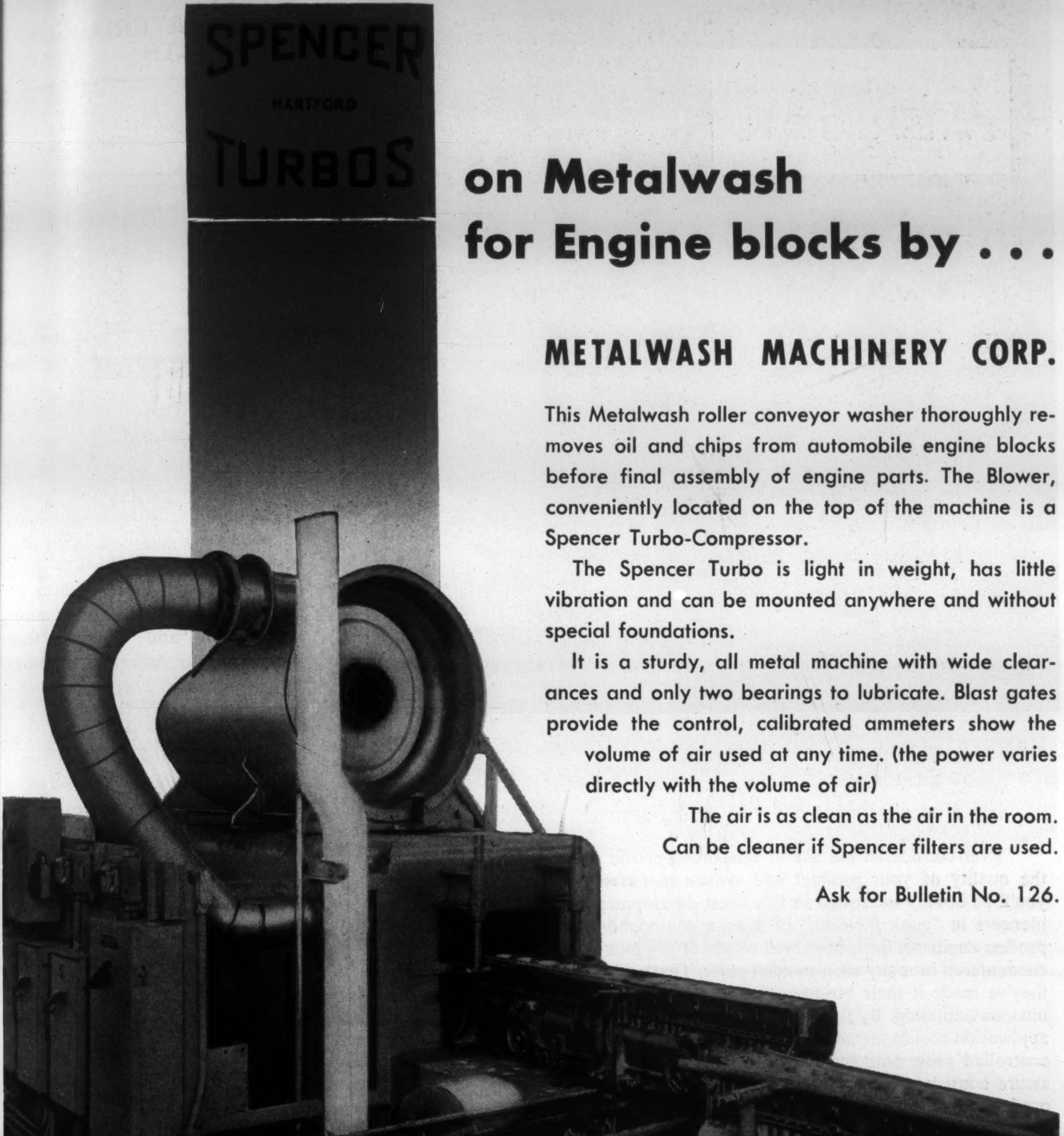
Three New Mechanical Fasteners



1. Set screw

A headless, self-locking set screw particularly suited for soft metal applications where vibration is a factor has been developed by *Set Screw Mfg. Co.*, Main St., Bartlett, Ill. The top of the screw is spread slightly causing a locking action with soft metal. The screw should be installed with a parallel shank screw driver so that engagement takes place at the bottom of the slot. After insertion of the screw, the screw driver can be moved from side to side, increasing holding power. The Spred-Lock Set Screw may be removed and re-used without appreciable loss of locking efficiency.

(Continued on p. 164)



on Metalwash for Engine blocks by . . .

METALWASH MACHINERY CORP.

This Metalwash roller conveyor washer thoroughly removes oil and chips from automobile engine blocks before final assembly of engine parts. The Blower, conveniently located on the top of the machine is a Spencer Turbo-Compressor.

The Spencer Turbo is light in weight, has little vibration and can be mounted anywhere and without special foundations.

It is a sturdy, all metal machine with wide clearances and only two bearings to lubricate. Blast gates provide the control, calibrated ammeters show the volume of air used at any time. (the power varies directly with the volume of air)

The air is as clean as the air in the room. Can be cleaner if Spencer filters are used.

Ask for Bulletin No. 126.

THE SPENCER TURBINE COMPANY

SPENCER
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HARTFORD 6
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SPENCER
TURBO-COMPRESSORS

Manufacturers of Turbo-Compressors and Heavy Duty Vacuum Cleaners

For more information, turn to Reader Service Card, Circle No. 338

What's new from
FABRICON

Typical reinforced plastic parts produced by Fabricon for the automotive industry

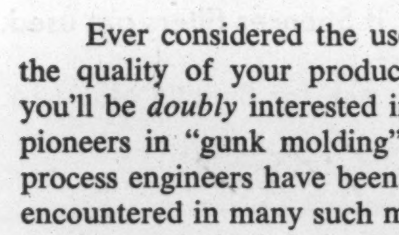
Laboratory control over new premix compounds provides GREATER UNIFORMITY OF STRENGTH in Fabricon-molded reinforced plastic parts!

Ever considered the use of reinforced plastic molded parts to *improve* the quality of your product and *reduce* manufacturing costs, too? If so, you'll be *doubly* interested in this latest development from Fabricon. For as pioneers in "gunk molding" of premix compounds, Fabricon chemists and process engineers have been well aware of the lack of uniformity commonly encountered in many such molded parts. That's why, during the past 5-years, they've made it their business to find ways and means of overcoming this obvious limitation. By the selection of proper basic materials to meet specific application requirements. And, too, by the development of special laboratory controlled processing techniques which assure consistent quality in the volume production of intricate, complex parts. As a result, Fabricon's new premix plastic moldings now possess far greater uniformity of strength than heretofore thought possible . . . plus a host of other desirable properties which highly recommend their use on countless different products, *yours included!*

Want more detailed information? Just outline the requirements of your particular application and send them in today!

PHYSICAL CHARACTERISTICS	PREMIX COMPOUND	
	MP-156 (Sisal)	MP-162 (Glass)
Flexural Strength, psi	11,200—13,400	14,800—18,300
Modulus of Elasticity in flexure—10^6 psi	1.17 — 1.40	1.20 — 1.72
Izod Impact Strength, foot-pounds/inch of notch	4.2 — 5.4	6.3 — 8.3
Water Absorption, % 24 hr.	1.78 Average	0.65 Average
Heat Distortion Temp.	392°F. (+)	392°F. (+)

Above values based upon tests conducted by independent laboratories in accordance with ASTM methods. Compounds listed are latest of over 150 grades developed and produced by Fabricon. Sample test panels gladly furnished upon request.



FABRICON PRODUCTS
1721 W. Pleasant Street
River Rouge 18, Michigan
A Division of EAGLE EP PICHER THE EAGLE-PICHER COMPANY

Reinforced Plastic Molded Products • Plastic Impregnated & Coated Materials

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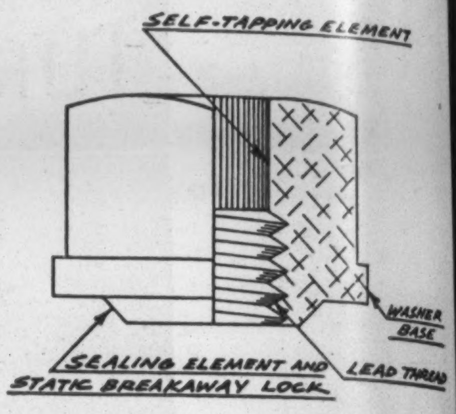
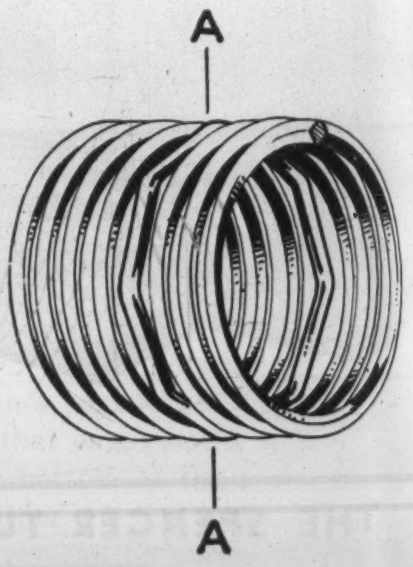
OTHER NEW MATERIALS, PRODUCTS



2. Nylon stop nut

The so-called Brilok nylon stop nut is a one-piece, washer-faced, hexagon nut said to be simultaneously self-tapping, locking and insulating. It is molded to American Standard Flats Widths Dimensions for use with standard installation and removal tools, according to the manufacturer, *The American Screw Co.*, Willimantic, Conn. As the screw turns into the nylon, the material is displaced and compressive forces are exerted against the screw as continuous drive-torque is applied, resulting in a tight friction lock. The nut is said to be reusable. The Brilok nut is stocked in natural nylon color, though other colors are available for coding, etc. It is currently available in sizes No. 4, 6, 8, 10, and ¼ in.



3. Locking insert

A new locking insert, called Mid-grip Screw-Lock, has been developed by *Heli-Coil Corp.*, Dan-

Tail section of North American F-100

vacuum-melted metals for "hotter" engines...

Vacuum-melted metals are breaking the "thermal-metal-barrier" of jet engine design. For they make possible higher engine operating temperatures, under conditions where conventional alloys fail rapidly.

Turbine blades of vacuum-melted superalloy, for example, were tested together with comparable blades of air-melted alloy. After 40 hours of operation the air-melted blades broke when bent less than 90° . . . the vacuum-melted blades took a full 180° bend without failure! For main shaft ball bearings, too, vacuum-melted metals far outperform conventional alloys.

Here's why . . . VACUUM MELTING LITERALLY SUCKS GASEOUS IMPURITIES FROM THE MOLTEN METAL...REMOVES INCLUSIONS AND GASSES THAT LIMIT THE PERFORMANCE OF CONVENTIONAL AIR-MELTED ALLOYS. RESULT: PURER METALS WITH EXCEPTIONAL PROPERTIES . . . LONGITUDINAL AND TRANSVERSE UNIFORMITY . . . HIGHER CREEP AND STRESS RUPTURE STRENGTH...BETTER DUCTILITY AND FATIGUE STRENGTH.

Vacuum Metals Corporation, pioneer in the development and production of vacuum-melted and cast alloys, is producing these unique new metals designed for a wide variety of aircraft applications. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

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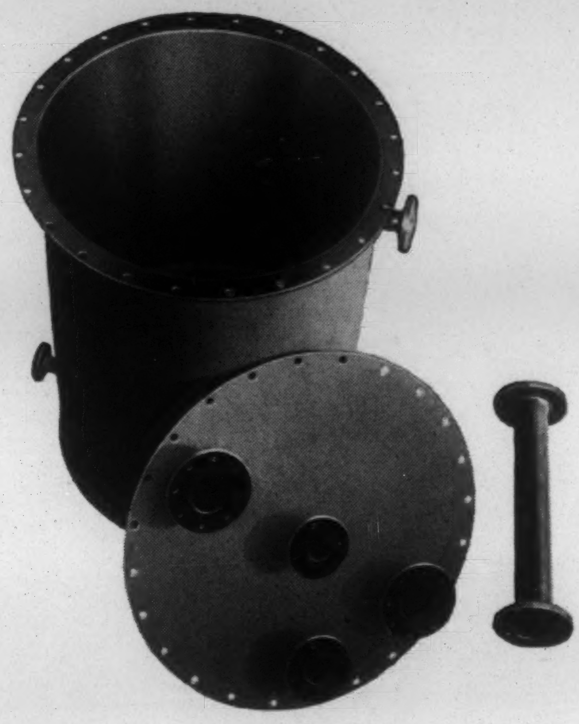


VYFLEX *FLIGID*® lining

stops sodium hypochlorite

The problem solved by lining the tank shown above with Fligid is particularly important because it is so widespread. Invaluable as an industrial bleach, sodium hypochlorite has a voracious appetite for just about every known lining or coating material. The bleach decomposes some on contact. It permeates others, raising gas blisters that force the lining away from the tank wall.

But nothing happens to *Fligid!* Sodium hypochlorite is completely powerless against this amazing new laminate of two different Polyvinyl Chloride based membranes. Furthermore, the cost of *lining* a tank with Fligid is *negligible* compared to the cost of *replacing* the tank.

The exposed face of *Fligid* is unplasticized PVC, able to resist the widest range of corrosives, at temperatures to 190 F in many solutions. There's no plasticizer to leach out and contaminate reagents. And this outer face is harder and more abrasion resistant than any other lining material. The inner face is resilient, flexible PVC, easily applied to steel, wood, or concrete, by simple adhesive bonding techniques with no curing. Qualified Kaykor applicators across the United States and Canada give fast, professional service applying *Fligid* to any size or shape structure in the field or in the shop.

GET THE FACTS! Write now for the complete story, including all technical data, in the just published technical sheet "Fligid"... free on request to Kaykor Industries, Inc., 4405 Broad Street, Yardville, New Jersey.

®

KAYKOR INDUSTRIES, INC.
Division of Kaye-Tex Manufacturing Corp.
YARDVILLE, NEW JERSEY

For more information, turn to Reader Service Card, Circle No. 395

bury, Mass. Use of the insert is said to eliminate need for lock-washers, lock-nuts and locking wires. The insert exerts a locking effect on a screw fastener because one or two coils in the middle of the insert are octagonal instead of being perfectly round. As the screw passes through this area, the gripping coils are forced to assume a circular shape. The chords press on the screw providing a locking force, which is said to be undiminished through many cycles of disassembly. Made of stainless steel wire, Mid-Grip inserts are installed with tools similar to those used for installing conventional wire screw thread inserts. The new inserts are currently available in sizes 10-32; 1/4-28; 5/16-24; and 3/8-24, with other sizes in NC and NF series through 1/2 in. scheduled for availability shortly.

Pressed Non-Woven Felt

A non-woven felt-like material called AllFab, consisting of a combination of textile fibers and a thermoplastics resin, is being produced by the *Felters Co.*, 22 West St., Millbury, Mass. Though the material has been available in limited quantities for the past six months, full production in a new plant is expected by the latter part of this year.

The material is made by depositing fibers in the form of a web and adding resin in powder form. Layers are built up to the desired thickness, then heat is applied, melting the thermoplastic powder and bonding the fibers. Fibers may be of any cardable type, such as Dynel, nylon, Dacron, or Orlon, either in their original condition or in the form of reused and reprocessed material.

AllFab can vary in thickness, density and width. In compact

Air Conditioning? *Heat exchange applications?* *Design?*

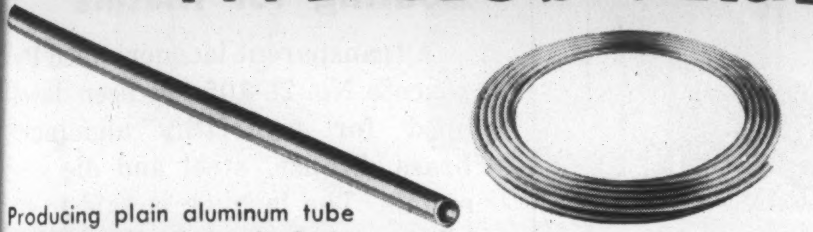
What are YOU doing in Aluminum?

MANUFACTURING REFRIGERATION EQUIPMENT?

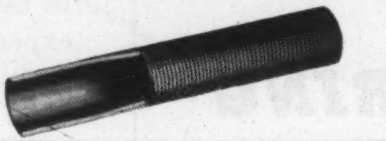
Furniture? **Building?**

GENERAL MANUFACTURING?

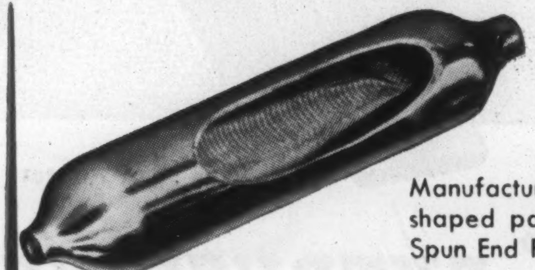
. . . Here's what WE'RE doing



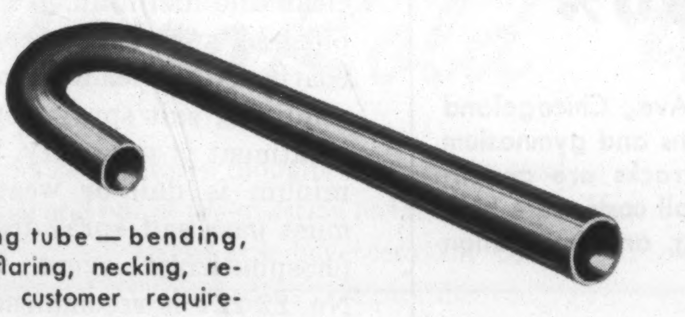
Producing plain aluminum tube —drawn or extruded—in straight lengths or coils.



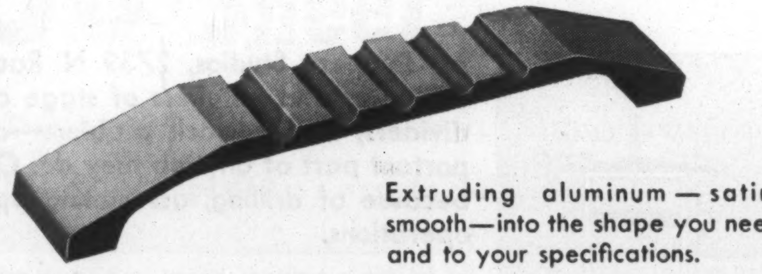
Making Wolverine Trufin* in a variety of alloys in drawn or extruded aluminum.



Manufacturing one-piece, tubular-shaped parts via the Wolverine Spun End Process**.



Fabricating tube — bending, beading, flaring, necking, reducing—to customer requirements.



Extruding aluminum — satin-smooth—into the shape you need and to your specifications.

. . . Let's get together!

If you are modernizing your products with aluminum . . . cutting their weight . . . improving their quality . . . let's get together.

You'll find there's quality-plus in Wolverine aluminum tube and shapes—the kind of quality that's built only through years of metalworking experience. Wolverine's Field Engineering Service team is at your beck and call to answer questions on alloy, design, fabrication. Write for your copy of the aluminum catalog. It's loaded with information you can use.

WOLVERINE TUBE, 1439 Central Ave., Detroit 9, Mich.

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

MANUFACTURERS OF QUALITY-CONTROLLED TUBING AND EXTRUDED ALUMINUM SHAPES

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**A PATENTED PROCESS RE. 22465

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EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

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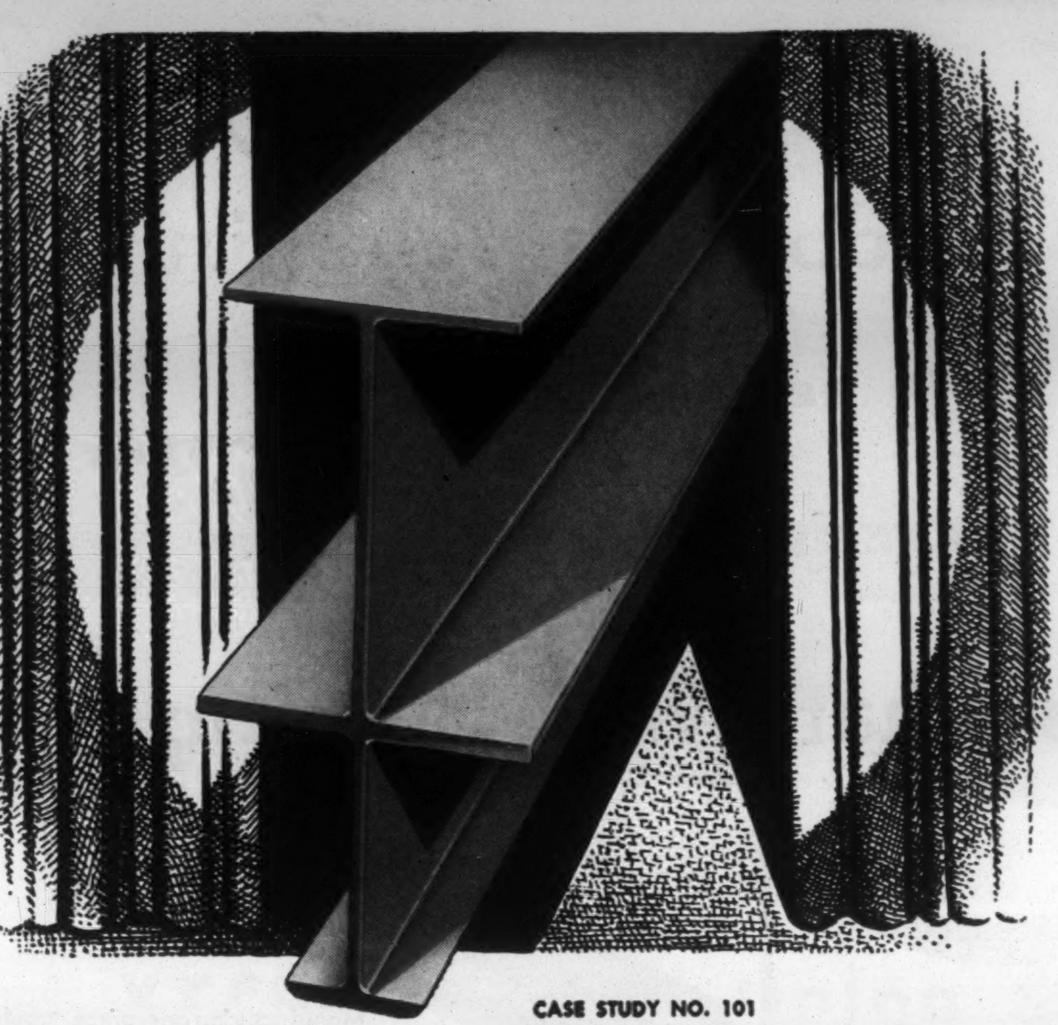
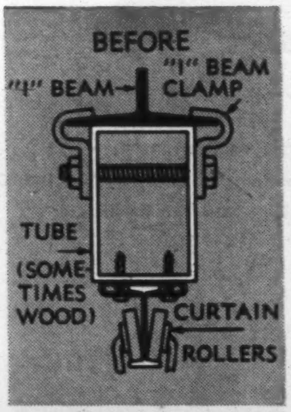
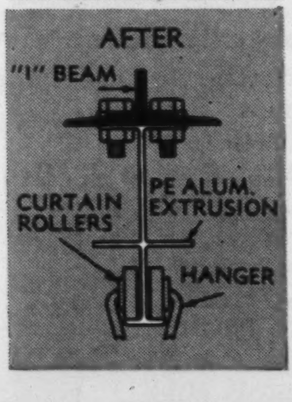
Art Drapery Studios rate repeated curtain calls



CASE STUDY NO. 101

HOW PE EXTRUSIONEERING*
CUT TRACK COSTS 50%





Art Drapery Studios, 2739 N. Racine Ave., Chicagoland designers and installers of stage curtains and gymnasium dividers, had a track problem—and tracks are an important part of any job they do. Over-all costs were high because of drilling, assembling, splicing, and installation operations.

THE PROBLEM AND SOLUTION

Could Precision Extrusions, Inc. design a one-piece extruded aluminum track that would solve these problems? As illustrated, PE engineered a track that eliminates drilling, assembling, and splicing operations; simplifies installation; makes it easy to curve the track right on the job. In addition, both material and labor costs are cut 50%.

*** WHAT IS EXTRUSIONEERING?**

"Extrusioneering" is a PE *plus* service designed to assist you in developing new ideas to solve specific problems, to cut manufacturing costs, and to improve product quality.

Most likely your need is far removed from curtain tracks; but why not call in a PE engineer and let him work with you towards a solution to *your* problem—whatever it is. There is no obligation.

PE
PRECISION EXTRUSIONS, INC.
727 E. GREEN AVENUE BENSENVILLE, ILLINOIS
PHONE: BENSENVILLE 98 • CHICAGO TUxedo 9-1701

Chicagoland's Oldest Aluminum Extruder

For more information, turn to Reader Service Card, Circle No. 394

form it can vary in thickness from 1/16 in. upward, and in looser, more resilient form can be produced in thicknesses up to 2 in. Width varies from 2 to 80 in. The resin binder can be varied to produce either a soft, medium or fairly compact product. Since the resin binder is thermoplastic, the material can be electronically sealed to other sheet material such as vinyls for use as automotive or furniture upholstery.

Clear Protective Coating for Metals

A transparent lacquer called Pyroxcote No. 26-105 has been developed for protecting aluminum, brass, bronze, steel and die cast metals. The lacquer is said to inhibit corrosion and weathering and to be non-yellowing under marine exposure. According to the manufacturer, *Pyroxylin Products, Inc.*, 4853 S. St. Louis Avenue, Chicago, Ill., the cured coating is easy to clean and maintain. It may be applied by spray, dip, brush or flow coating. On clean aluminum not requiring salt spray tests, no pretreatment is necessary. When aluminum is dull or weathered, or must pass salt spray tests, use of phosphatizing agent Prox-Prep No. 22-227 is recommended.

Lacquer Thinner Increases Coating Thickness

Film thickness of sprayed lacquer coats can be increased by as much as 100%, according to *Potter Paint Co., Inc.*, 38 Crawford St., Cortland, N. Y. manufacturers of Hi-Sol thinner. The increased thickness is said to be caused by the action of the thinner, which increases the viscosity of the lacquer rapidly between the point of exit from the spray gun and the point of impingement on the surface to be coated. This action is also said to reduce sagging. The thinner is said to improve flow, gloss and blush resistance of lacquers.

(More New Materials on p. 170)

Looking For
LOW COST
Stainless Steel?

...then you want

MicroRold® 430 Sheet

Perhaps you have always thought of stainless steel as a luxury material and out of the question as far as your product is concerned . . . or maybe you have seriously considered using stainless steel only to find its cost prohibitive . . .

True, some grades of stainless steel are relatively expensive, but this is because they possess higher degrees of corrosion resistance, absolutely necessary in some highly corrosive applications. This is not the complete story, however, as there are other less expensive grades of stainless having sufficient corrosion resistance without sacrificing the other desirable stainless steel qualities of beauty, strength, long life, workability and ease of maintenance.

If extreme corrosion resistance is not a factor in your product, it would be unnecessary and costly to specify a higher grade of stainless than required.

This is where MicroRold 430 enters the profit picture...

MicroRold Type 430 is a straight chromium-stainless with a nominal composition of 17% chromium. Though it is less resistant to corrosion, it retains all of the other desirable qualities of stainless and has proven very satisfactory in a wide range of mild corrosion applications.

MicroRold 430 is the least expensive of our stainless types because it does not contain nickel. This results in a 7¾c per pound difference in base price between Type 430 and Type 302, the most popular higher grade stainless. A saving of $155 per ton is possible and is of merit to cost-conscious fabricators.

MicroRold Type 430 sheets are available in thicknesses .005″ to .109″ with 2B or 2D finishes; and in thicknesses .010″ to .109″ in No. 3, 4 and 7 finishes.

Send for your copy, "Care and Use of 430 Stainless"

Washington Steel
Corporation

2-F WOODLAND AVE. WASHINGTON, PENNSYLVANIA

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OTHER NEW MATERIALS, PRODUCTS

Flat Drawn Wire

Flat, diamond-die drawn wire, in any conventional alloy, is being produced to tolerances of plus or minus five millionths of an inch by *Instrument Wire Co.*, 41 Kendall Ave., Maplewood, N. J. Flat drawing is said to provide the wire with longitudinal grain, as well as improve cold working, making a harder, tougher and stronger ribbon-wire. Diamond dies are said to impart a polished finish to the wire, improving fatigue and corrosion resistance characteristics. Wire can be drawn in any size from 0.003 by 0.0003 in. to 0.060 by 0.025 in. Any combination of these dimensions can be drawn flat, of any metals ordinarily drawn by conventional round-die methods. Torque variations in springs made of the wire are said to be less than variation errors found in available torque measuring devices.

Anti-Static Finish for Synthetic Fibers

An anti-static finish for synthetic textile fibers has been developed which will withstand repeated washing and dry cleaning and is compatible with resins, repellents, stiffening agents and softeners. Called Niatex antistatic AG-2, the vinyl type compound is being marketed by the *Carbide and Carbon Chemicals Co., div. of Union Carbide and Carbon Corp.*, 30 E. 42nd St., New York 17. The finish is said to be easy to apply by diluting with water and padding or spraying, yet is difficult to remove from fabrics made of such fibers as Dynel, Orlon, or Acrilan. No catalyst or high-temperature cure is required. On Dynel fabrics, extent of antistatic protection is such that fabrics show no dirt pick-up after rubbing on wool, zero voltage as measured on suitable electrostatic voltmeter after similar rubbing, and a volume resistivity of less than 5×10^9 ohm/cm^2.

(*Continued on p.* 173)

For more information, Circle No. 301 ▸

OTHER NEW MATERIALS, PRODUCTS

The finish is a viscous, white- to light amber liquid which can be mixed with water or any of a variety of organic solvents. It is compatible with many types of resins, water repellents, stiffening agents and softeners. The anti-static durability of combinations of finishing materials with AG-2 varies somewhat and the producers recommend testing in specific cases. According to the producers, the new finish is most effective on fibers with irregular cross-sections.

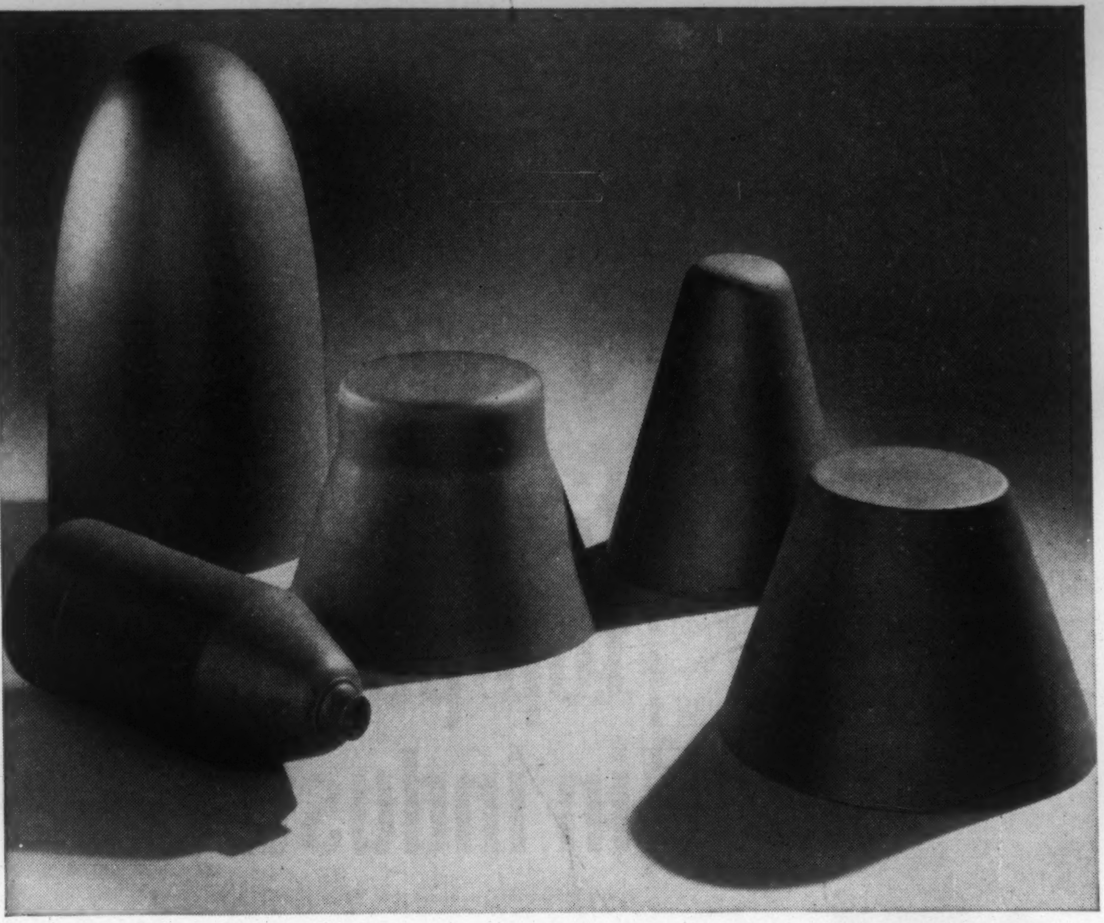
Thick Acrylic Sheet

Cast acrylic sheet, 5 to 10 in. in thickness, is being produced by *Cadillac Plastic and Chemical Co.*, Detroit, Mich. The sheet is said to be clear with no flaws or bubbles. It eliminates the necessity for laminating to obtain desired thickness for many applications. It is expected to find use in the optical industry and for scale models and prototypes, observation shields, pressure vessels, insulators, decorative fixtures, three-dimensional displays, structural blocks and similar applications. It is available in 24-x 24-in. sheets.

Fluorocarbon Lubricant

A fluorocarbon lubricant, Kel-F # 90 grease, is said to feature a high degree of lubricity, high chemical resistance and can be easily removed. It is recommended for use with metal, glass, plastics or ceramics parts. Produced by *Scientific Glass Apparatus Co., Inc.*, Bloomfield, N.J., the grease is operative over a service temperature range of 0 to 350 F, is non-melting, non-corrosive and resistant to water washout. It is said to be particularly well suited for lubrication of laboratory and industrial equipment handling strong acids, oxygen, ozone, oxidants, halogens and other corrosive or reactive chemicals.

(Continued on p. 174)



What you ought to know about deep drawn shapes and shells

Hackney deep drawn shapes and shells permit product designers to reduce weight, save production time and lower unit costs—improve product appearance, increase strength and vibration resistance. Our experience in producing O.E.M. parts for manufacturers of many types of equipment can help you achieve similar results. Just keep these basic specifications in mind:

Shapes: Cylindrical, spherical, tapered or conical.

Capacities: From 1 quart to 70 gallons.

Diameters: From 3 inches up to 32 inches.

Depths: Up to 60 inches. Two half shells are easily welded together for extra length or symmetrical design. Open end can be closed by spinning to give an entirely seamless cylinder.

Blank thicknesses: 16 gauge and heavier.

Wall thickness: For working pressures up to 5,000 psi in the smaller diameters—up to 200 psi in the larger diameters.

Metals: Steel, stainless steel, nickel, aluminum, magnesium, copper and many alloys.

Write for details.

Pressed Steel Tank Company
Manufacturer of Hackney Products

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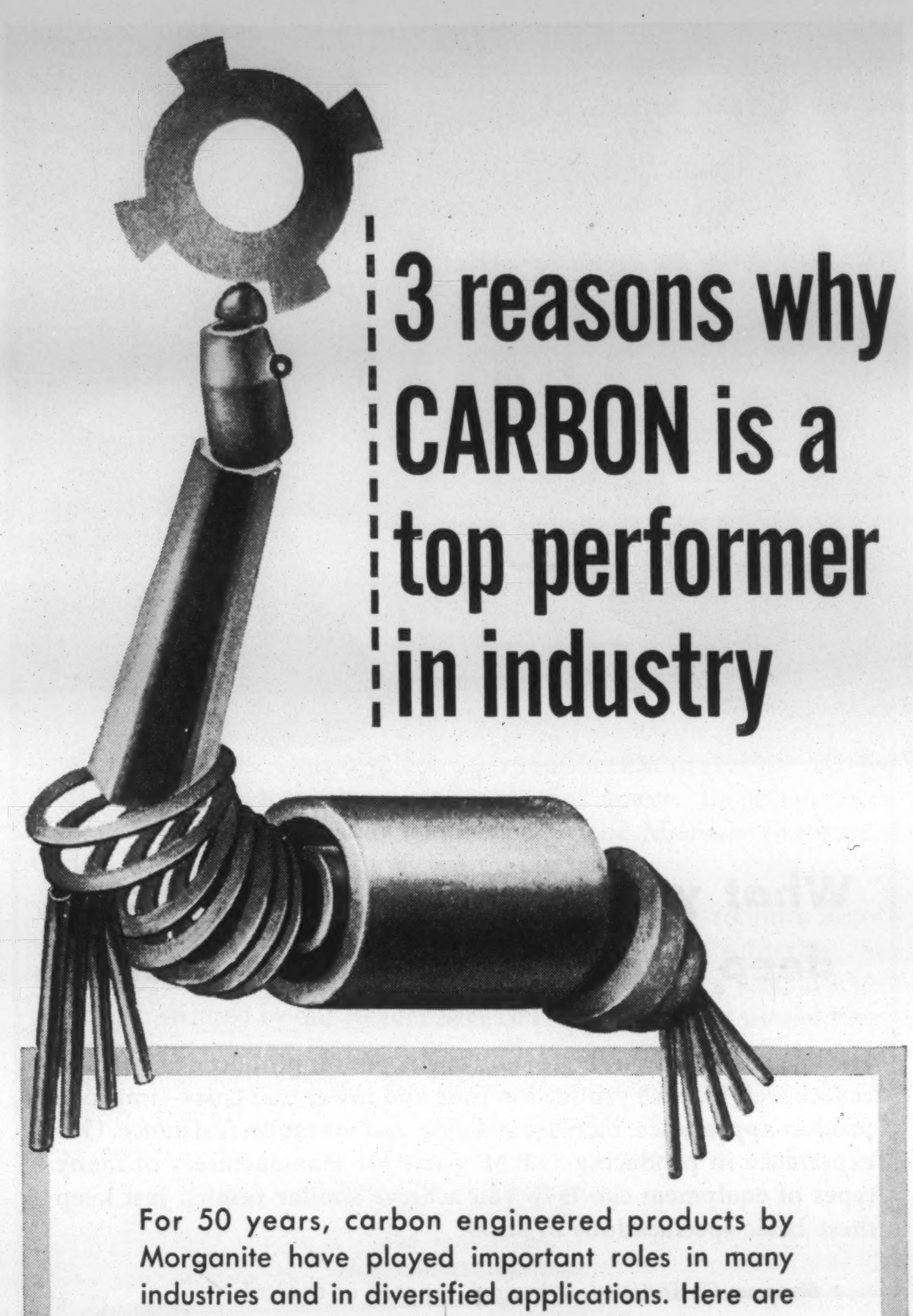

3 reasons why CARBON is a top performer in industry

For 50 years, carbon engineered products by Morganite have played important roles in many industries and in diversified applications. Here are just three outstanding examples:

- ***In the textile and chemical industries,* self-lubricating carbon-graphite bearings eliminated the danger of oil and grease lubricants.**
- ***In industrial and electrical generating plants,* heat-resisting carbon bearings solved problems where high temperature prohibited the use of conventional lubricants.**
- ***In food processing plants,* inert carbon pump vanes and seals solved the problem of product contamination.**

Morganite's Engineering Staff is always ready to help with your design or maintenance problems. Write today for Morganite's brochure on Carbon Specialty Products.

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Manufacturers of fine carbon-graphite products for 50 years
3304 48TH AVENUE, LONG ISLAND CITY 1, NEW YORK

For more information, turn to Reader Service Card, Circle No. 441

The grease is based on polychlorotrifluoroethylene oils and waxes and can be removed for cleaning purposes with chlorinated solvents or ketones. It has been used successfully in the presence of bromine, chlorosulfonic acid, hydrogen fluoride, aluminum chloride, fuming sulfuric acid, phosphorous oxychloride, sulfan chlorosilanes, antimony trichloride, nitrosylsulfuric acids, hydrogen peroxide and red and white fuming acid. According to the manufacturers, it has also been found to be the most satisfactory lubricant for use in contact with chromyl chloride and chromyl nitrate.

Wider Magnesium Sheet Stock

Magnesium alloy sheet in thicknesses of 0.064 in. and upward is now being produced in standard widths up to 72 in., by *The Dow Chemical Co.*, Midland, Mich. Sheet 0.040 and 0.051 in. thick is available in standard widths up to 60 in.

Glass-Dacron Yarn for Insulation

A glass-Dacron yarn, primarily intended for use in abrasion-resistant insulation, is being produced by *L.O.F. Glass Fibers Co.*, 1810 Madison Ave., Toledo 1, Ohio. In addition to its long life and abrasion-resistant qualities, it can withstand considerable abuse encountered in processes of manufacturing motors, generators, and transformers. It is well suited for use on magnet wire, for aircraft electrical cable construction and for sleeving and tubing. It is supplied wound on serving or braider packages.

CONTENTS NOTED

A digest of papers, articles, reports and books of current interest.

This Month:

- *The latest in close tolerance casting*
- *Protective coatings for molybdenum*
- *Creep of reinforced plastics*
- *Properties of ceramics*
- *Alternate for nickel-chrome plate*

Recent Developments in Close Tolerance Casting

- *Glascast Process*
- *Investment X*
- *Shaw Process*

Several new processes have recently appeared for producing castings with improved surface finish, dimensional control, flexbility of shape, and/or greater control of metallurgical structure. In a paper delivered before the annual fall meeting of the Investment Casting Institute in Detroit last November, Dr. N. J. Grant of M.I.T. described these newer processes and pointed out advantages and limitations in their use.

As with the Mercast process or the resin shell process, the Glascast process avoids the precoat step normally necessary in investment casting, while achieving a very fine surface finish. The Glascast process produces a slip cast shell of finely crushed silica glass, which has a low thermal expansion providing the shell with excellent thermal shock resistance.

The model may be of any machinable material which can take a high finish and which will meet dimensional requirements. Undercuts must be eliminated and draft allowed. A pattern either of dense plaster or soft metal is made from the model, and the porous plaster mold is made from this pattern. The plaster mold will probably make from 15 to 20 glass shells before some surface and dimensional deterioration. If dimensions or surfaces are not critical, up to 100 or more impressions may be made.

Glascast slip, made by mixing Glascast powder with water, is poured into the mold and allowed to build up to a thickness of about ⅛ in., after which surplus slip is poured off. After drying for 10 or 15 min at 140 F, the Glascast shell is removed from the mold, oven-dried and baked. The two halves are then assembled, preheated and the castings poured. Casting can be done by gravity feed, pressure or vacuum.

In producing parts by the Investment X process, wax patterns

Glascast

Advantages of the process are:

1. Forty microinch finish is readily attainable.
2. Extremely thin sections are easily cast by a hot mold.
3. Inherently the process promises dimensional control of ±0.005 in. per in.
4. Acceptable casting yield based on surface condition is one of the highest noted for any ceramic casting process, due primarily to elimination of precoat practice.
5. Low tooling costs.
6. Metal pouring temperatures may be 3200 F or higher without reaction, using shell preheat temperatures up to 1800 F. Aluminum, brass, carbon steels, stainless steels, cobalt base alloys and chromium base alloys have been successfully cast.
7. Short lapse of time from mold preparation to casting.

Weak points of the process are listed as:

1. Parting line variations constitute the major difficulty since shells to bow slightly during release from plaster.
2. Care must be taken to avoid hot tearing by permitting the shell halves to be separable.
3. All corrections must be made in master pattern since there is no correction through shell expansion.

Investment X

Major advantages seem to be as follows:

1. Larger castings are possible than with lost wax or plastics investment casting.
2. Permeability of shell is greater as compared to dense structure of solid investments.
3. Mold cracking is diminished.
4. Process advantages are: simpler handling of molds, reduced weight of casting assembly, less floor space necessary, lower pouring temperatures, improved wax removal and recovery, and feasibility of hollow wax patterns.

Problems encountered with the process include:

1. Handling of toxic trichlorethylene vapors in foundry.
2. Cost factor involved in losses of trichlorethylene.
3. Coating and investment costs.
4. Precoat crack and spalling frequency.

(Continued on page 178)

more important
NEW DEVELOPMENTS
from
THE CHEMICAL CORPORATION
Research Laboratory

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A dark, hard, stable olive drab coating. Applied in about 15 seconds at room temperature. Gives maximum corrosion protection. Meets most rigid specifications. Available in one package.

LUSTER-ON D

A powdered product to produce a bright clear conversion coating on zinc and cadmium.

LUSTER-ON ACTIVATOR

Designed for preparing a zinc alloy die casting prior to treatment in our Luster-On acid baths. Also serves as a mild cleaner. However, heavy soil must be handled by a precleaner.

LUSTER-ON NS

The answer to "spotting out" troubles on thin copper and brass plate, especially under humid conditions. Improves adhesion, provides leveling action, saves lacquer. Eliminates fingerprints before assembly.

LUSTER-ON ALUMINUM SEALER (222-M)

Produces a chromate film on aluminum that provides excellent corrosion protection and can serve as a paint base. Now can be dyed in many attractive pastel colors. Meets requirements of Government Spec. MIL-C-5541.

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Ask for literature. Send a sample for free laboratory treatment.

Luster-On products are manufactured on the West Coast by Crown Chemical and Engineering Company of Los Angeles, Calif., and in the Dominion of Canada by Alloycraft Limited of Montreal, Quebec.

You'll also be interested in our Safety Division's line of industrial skin cleaners and protectors . . . protect your workers and your products. Literature available.

L-18

THE Chemical CORPORATION
67 WALTHAM AVENUE
SPRINGFIELD, MASS.

For more information, Circle No. 314

CONTENTS NOTED

Stainless steel pattern *shown here illustrates size of castings made with Glascast process.*

are assembled in the usual manner. They are then spray or dip-coated with conventional coating compositions involving ethyl silicate. The coated wax pattern is showered with coarse fired molochite and tunnel dried between coatings. Coating step is repeated 6 to 8 times to build up a shell about ¼ to ½ in. thick. Wax patterns are then removed by immersion in trichlorethylene vapor rather than melting, and the resulting shell is packed in a flask and supported by a granular refractory for preheating and casting. Immersion is used to remove wax because heating to melt the wax would crack the investment shell.

The Shaw Process is a split mold process preferably using a metal pattern which is a positive of the part to be cast. The mold material is a sand-tetraethylsilicate bonded slurry. In the process of setting the slurry becomes a gel possessing some elasticity. In this condition, the mold can be easily stripped from the pattern, which may have some reentrant angles. Ultimately the gel converts to a finely deposited silicon dioxide which provides the high temperature bond. After stripping, alcohol is burned off, drying the mold.

Shaw Process

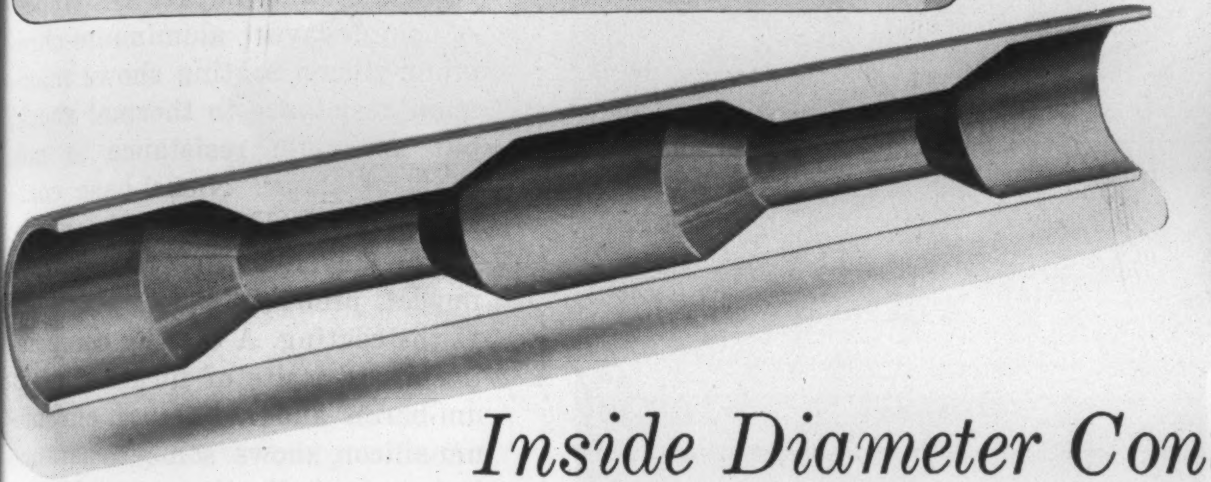
Advantages of the process include:

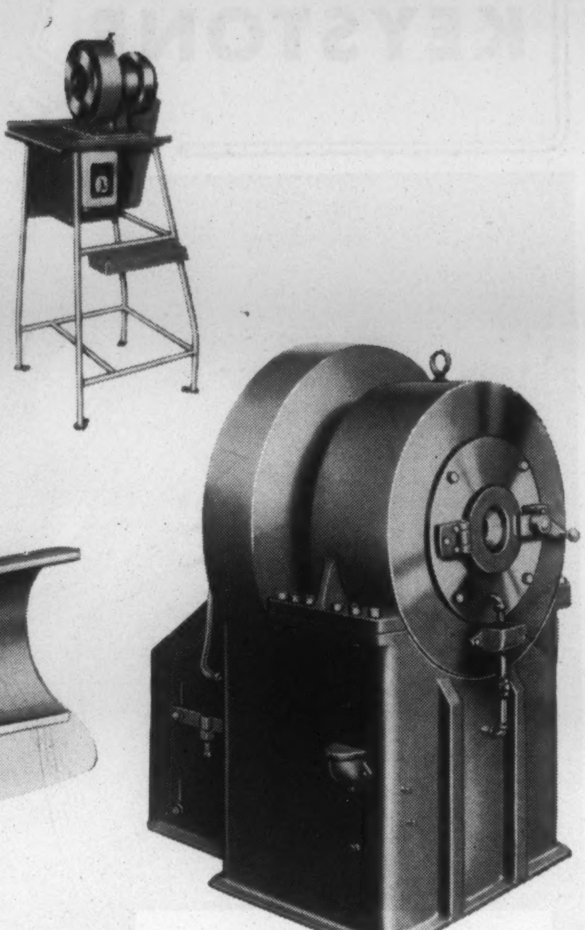
1. Avoidance of a disposable pattern material.
2. Avoidance of precoat and attendant problems.
3. Larger castings.
4. Ease of stripping molds from models.

Major problems involved in the process seem to be a relatively slow production rate for molds and high die costs.

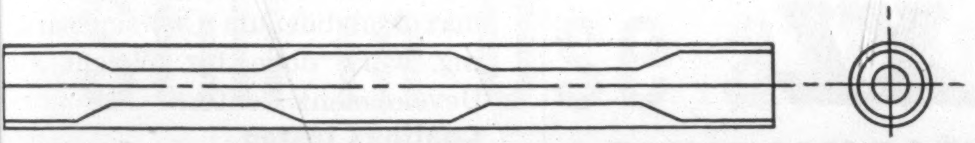
(More Contents Noted on p. 180)

Swaging Success Stories

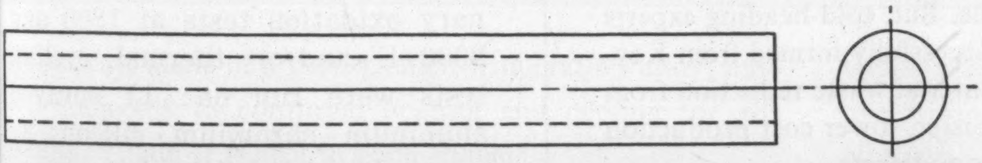




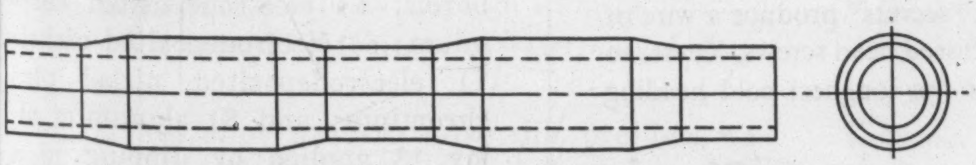
Inside Diameter Contours
. . . Easily Produced by Swaging



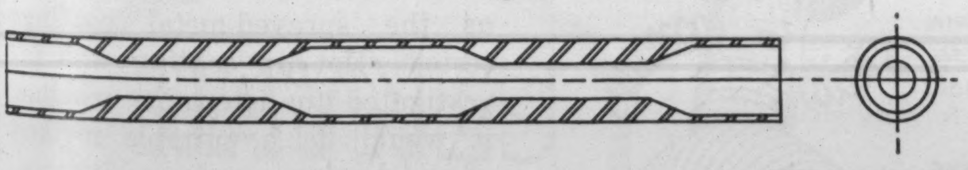
Machining multiple-diameter contours on the inside of cylindrical pieces (Fig. 1) is a difficult, time-consuming job.



Torrington's Swager experts start with tube of larger OD (Fig. 2) and machine the blanks to predetermined outside shape (Fig. 3).



Simply by swaging the outside to a straight, uniform diameter, the intricate contours are transferred to the inside (Fig. 4). Result: a sizeable saving in machining costs.



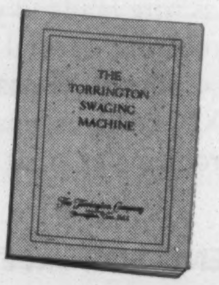
Swaging Advantages . . .
No Chips . . . No Waste . . . No Scrap

Swaging reduces metal—saves material—does not cut it away wastefully.

Swaging work hardens metal—gives it added strength, better finish and resiliency, dimensional accuracy.

Swaging is fast—can be done by unskilled workers to produce more pieces at lower cost.

Write for our informative booklet on Swaging that gives detailed descriptions of Torrington Rotary Swagers. It may show you how to achieve new savings in your own plant.

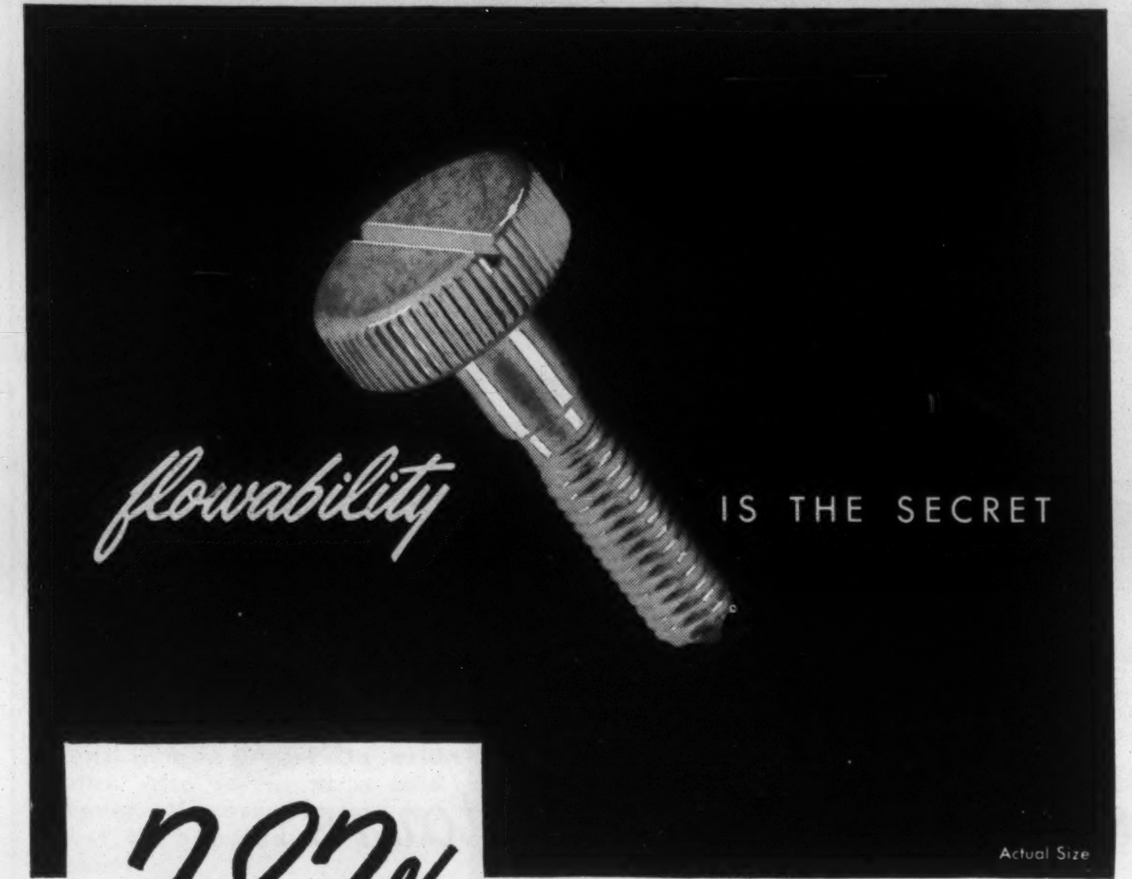


THE TORRINGTON COMPANY
Swager Department
660 North Street, Torrington, Conn.
Makers of Torrington Needle Bearings

TORRINGTON ROTARY SWAGING MACHINES

For more information, turn to Reader Service Card, Circle No. 345

KEYSTONE XL COLD HEADING WIRE



282% MATERIAL SAVED...

USING KEYSTONE XL COLD HEADING WIRE

This circuit breaker part was machined at one time. But, cold-heading experts analyzed its design and decided that it could be successfully formed from Keystone "XL" Cold Heading Wire. The result—a material waste reduction from 75% to 7%—and a saving of 282% in steel, plus faster, lower cost production and a finished product that is stronger and free from defects.

Keystone "XL" Cold Heading Wire is not just ordinary cold heading wire. It is wire made to your specific order to exactly solve your difficult cold heading problems. Special drawing, annealing and coating "secrets" produce a wire of exceptional *flowability*. Originally developed for recessed head screws, Keystone "XL" Wire is now widely used to solve many of the toughest cold heading problems at great savings in time and money.

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KEYSTONE WIRE for Industry

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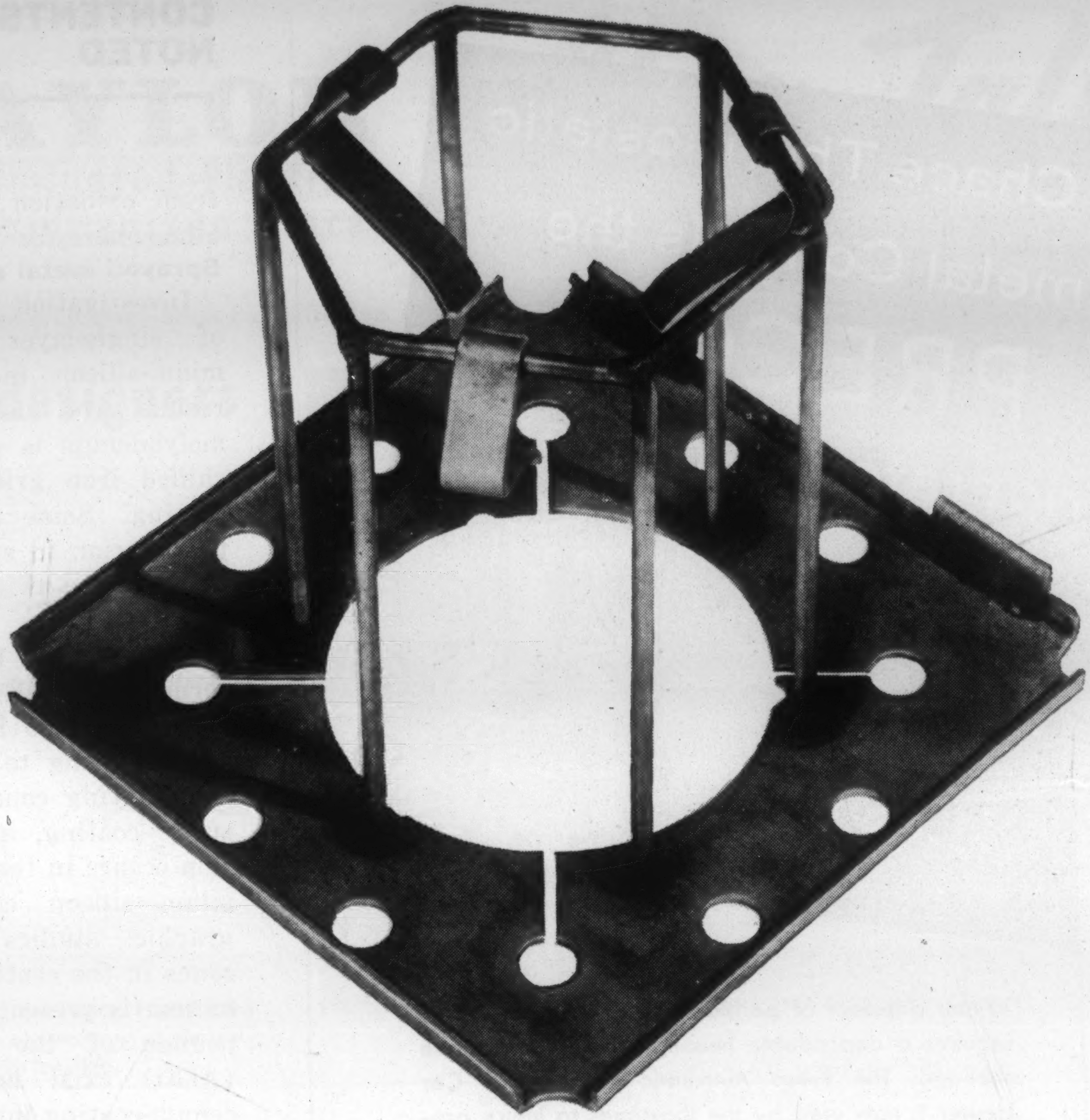
CONTENTS NOTED

Oxidation-Resistant Coatings for Molybdenum

In protecting unalloyed molybdenum from oxidation at temperatures of 1800 to 2000 F, sprayed metal coatings have been found to provide the best protection. Of the coatings examined they have the best combination of thermal shock resistance and impact resistance. A single-layer aluminuum-chromium-silicon coating shows maximum resistance to thermal shock, but minimum resistance to mechanical shock. Nickel-base coatings, which distort badly under thermal cycling, are resistant to impact, probably due to plasticity of the coating. A coating comprising a composite of nickel-chromium-boron and aluminum chromium-silicon shows some resistance to impact, indicating possible justification for future work with composite coatings. Results of experiments are detailed in a report by J. R. Blanchard of Climax Molybdenum Co., summarizing work done for Wright Air Development Center.

Coatings tested

Tests were carried out on coatings applied by spraying, electroplating and hot dipping. Preliminary oxidation tests at 1800 and 2000 F and/or thermal cycling tests were run on: 1) sprayed aluminum - chromium - silicon; 2) sprayed nickel-chromium-boron; 3) sprayed composites of 1) and 2); 4) sprayed nickel-silicon-boron; 5) electrodeposited chromium; 6) electrodeposited nickel; 7) electrodeposited nickel plus chromium; and 8) aluminum alloy 13 applied by dipping in a molten bath. In general, none of the electrodeposited coatings withstood thermal cycling as well as the sprayed-metal coatings tested. Hot-dip coating was investigated to determine whether it would be a suitable method of protecting surfaces inaccessible to the metallizing gun. Requirements for oxidation-resistant coatings for molydenum have been established as protection



Still in Use after 1½ Years of Heating and Quenching

This tray, made of a Haynes high-temperature alloy, has been subjected to continual heating and cooling for 18 months . . . and it is still in good shape.

In the heat-treating operation, trays and rings are heated to 1550 deg. F for a half hour and then given a rapid oil quench. This repeated exposure to high temperatures and thermal shock caused other trays to twist out of shape in a few days.

The Haynes alloy used to solve this problem was Hastelloy alloy C. There are 10 other Haynes high-temperature alloys—each designed to resist certain severe operating conditions. All of the alloys have remarkable strength at high temperatures, coupled with excellent oxidation resistance and dimensional stability. One of them may be the answer to a production or maintenance problem in your plant.

For information on prices, available forms, and properties of these alloys, write to our general sales office in Kokomo, Indiana or to any of the District Sales Offices listed below.

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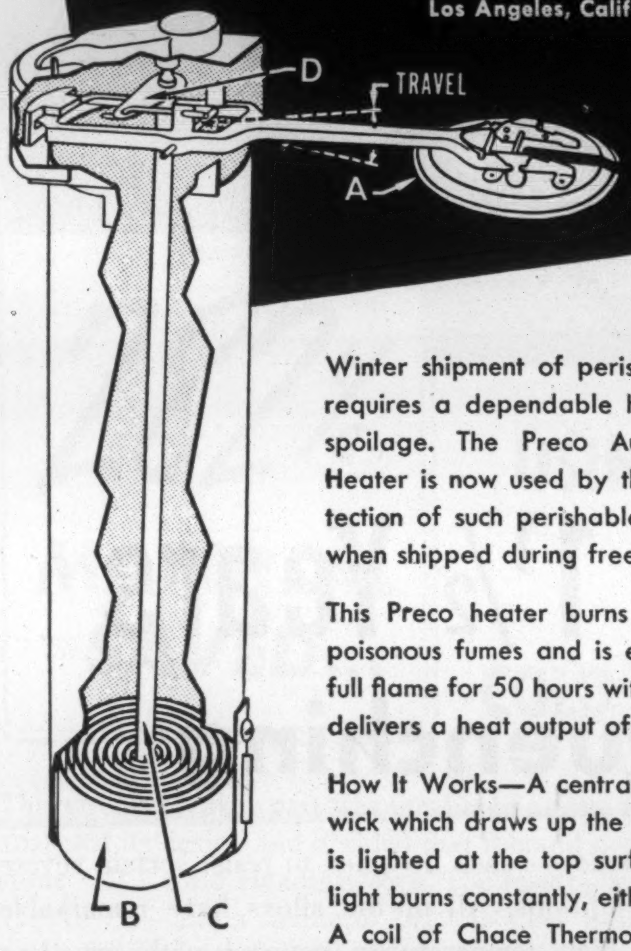
How Chace Thermostatic Bimetal Controls the PRECO Refrigerator Car Heater

Products of
PRECO, Inc.
Los Angeles, California



Winter shipment of perishables in refrigerator cars requires a dependable heating device to eliminate spoilage. The Preco Automatic Refrigerator Car Heater is now used by the thousands to insure protection of such perishables as fruits and vegetables when shipped during freezing weather.

This Preco heater burns methanol which eliminates poisonous fumes and is explosion proof. It burns on full flame for 50 hours with one tank of methanol and delivers a heat output of 6000 BTU's per hour.

How It Works—A central tube contains a spun-glass wick which draws up the methanol from the tank and is lighted at the top surface. In operation, the pilot light burns constantly, either on pilot or on full flame. A coil of Chace Thermostatic Bimetal (B) regulates the degree of combustion by controlling the amount of oxygen admitted to the wick, according to the temperature in the car. The bimetal coil, with one end fixed to the housing and the other to the shaft (C), reacts to temperature change by rotating the shaft with lever (D) attached, lifting or lowering the snuffer arm and plate (A) over the flame. Thus, the amount of oxygen available for combustion is varied to produce a greater or lesser degree of heat.

Chace Thermostatic Bimetal is available in 29 types, in strip, coils or in complete elements made to your specifications. Write now for our free 36-page booklet, "Successful Applications of Thermostatic Bimetal," containing valuable information for designers of thermally responsive devices.

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W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

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from oxidation in a moving air atmosphere for 500 hr at 1800 F.

Sprayed metal coatings

Investigation of spray-coatings of single-layer aluminum-chromium-silicon indicate that best results are obtained when the molybdenum is grit blasted with chilled iron grit prior to spray coating. Some oxidation of the panel prior to spray coating can be tolerated without sacrificing protective life. Panel thickness can range up to 1/8 in., and sharp corners increase probability of failure at 1800 F.

By heating to 2000 F for one hour during consolidation of the spray coating, appreciable diffusion occurs in the aluminum-chromium - silicon coating. Metallographic studies show several zones in the coating. No free aluminum is present, but cubic compounds of the type $(MoCr)_3$-(Al,Si) exist near the molybdenum-coating interface. Presence of Al_2O_3 was indicated near the outer surface of the sample oxidation-tested for 200 hr, but may have been formed by residue from the slurry used in diffusion treatment. A comparison, after 500 hr, of weight changes of panels cooled daily to room temperature from the 1800 F oxidation test with panels continuously exposed at 1800 F, showed both sets to have increased approximately 0.05 mg per sq in. of surface area.

A ballistic impact test was constructed, in which test panels could be heated to elevated temperatures, then subjected to edge impact by a steel pellet projected at a controllable muzzle velocity from an air rifle with the muzzle 1/2 in. from the specimen. The aluminum-chromium-silicon coating, which had shown best results from other tests, spalled in the ballistic impact test at 1800 F at a muzzle velocity of 330 ft per sec. The base molybdenum started to oxidize immediately after spalling. The same coating did not spall at 135 ft per sec muzzle velocity, and protected the base molybdenum from detectable oxi-

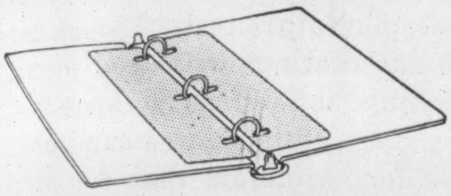
TAYLOR
Laminated Plastics
Vulcanized Fibre

Shop Talk

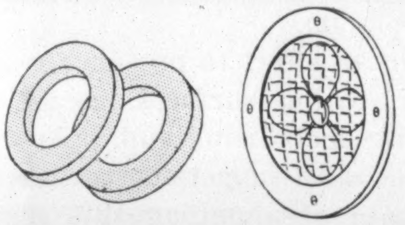
TAYLOR FIBRE CO.
Plants in Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • VULCANIZED FIBRE • POLYESTER GLASS ROD

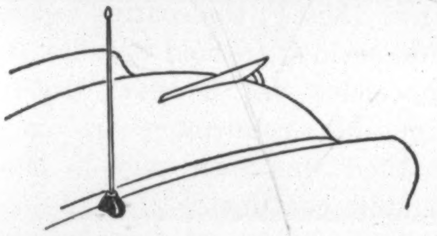
Tips for designers



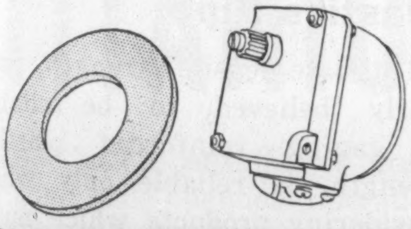
Flippers for loose-leaf binders are made of economical Taylor Vulcanized Fibre . . . affording added rigidity and good protection for the paper pages.



Large exhaust fans use Taylor Paper Base Phenolic washers to help absorb thrust . . . an inexpensive arrangement, with long life.



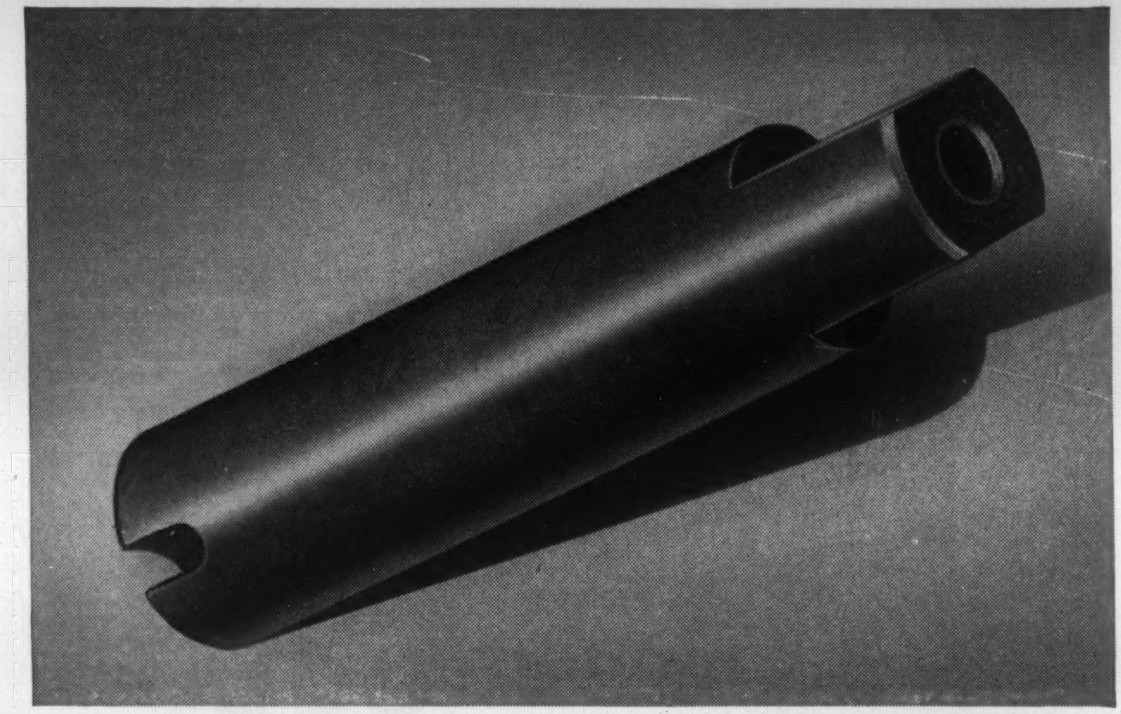
Radio antennas for the colorful, new cars may be made from equally colorful Taylor Polyester Glass Rod, with a copper wire center.



Self-balancing servo motor has stator case insulator which is cold-punched from 1/64" thick Taylor Paper Base Phenolic Laminate sheet.

VISIT WITH TAYLOR AT THE I.R.E. SHOW

Qualified technical personnel will be on hand in the Taylor booth (#675) at the I.R.E. Show in New York's Kingsbridge Armory, March 19 through 22. Visit with Taylor while you're at the show and discuss your application requirements as well as the latest advancements in high-performance laminates.



This impeller shaft, used in the famous Hotpoint Dishwasher, is easily and economically fabricated from Taylor Paper Base Phenolic Tubing.

Fabrication ease holds down costs —when you use Taylor laminates

Economy-minded designers and production managers are discovering plus qualities in the excellent fabricating properties of Taylor phenol, melamine, silicone and epoxy laminates. In addition, the large sheet size and choice of forms in which these materials are supplied make for further economy in utilization . . . through maximum yield of purchased stock.

This outstanding ease of fabrication is not happenstance . . . for all Taylor laminates are the result of resin formulations and production techniques designed to facilitate economical conversion to completed parts. Punching, staking, milling, sawing, drilling . . . you'll find it's easier when you use a Taylor basic material.

Included in the broad selection of Taylor laminates are a great variety of different bases and different grades . . . each with its own combination of electrical and physical properties, qualifying it for a specific application at a reasonable price.

And, here's another *plus!* Your production problems can be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced . . . by having your finished parts prepared to your specifications in the Taylor Fabricating Division. Valuable experience coupled with complete facilities are ready to serve you. Call on Taylor for a discussion of your particular requirements.

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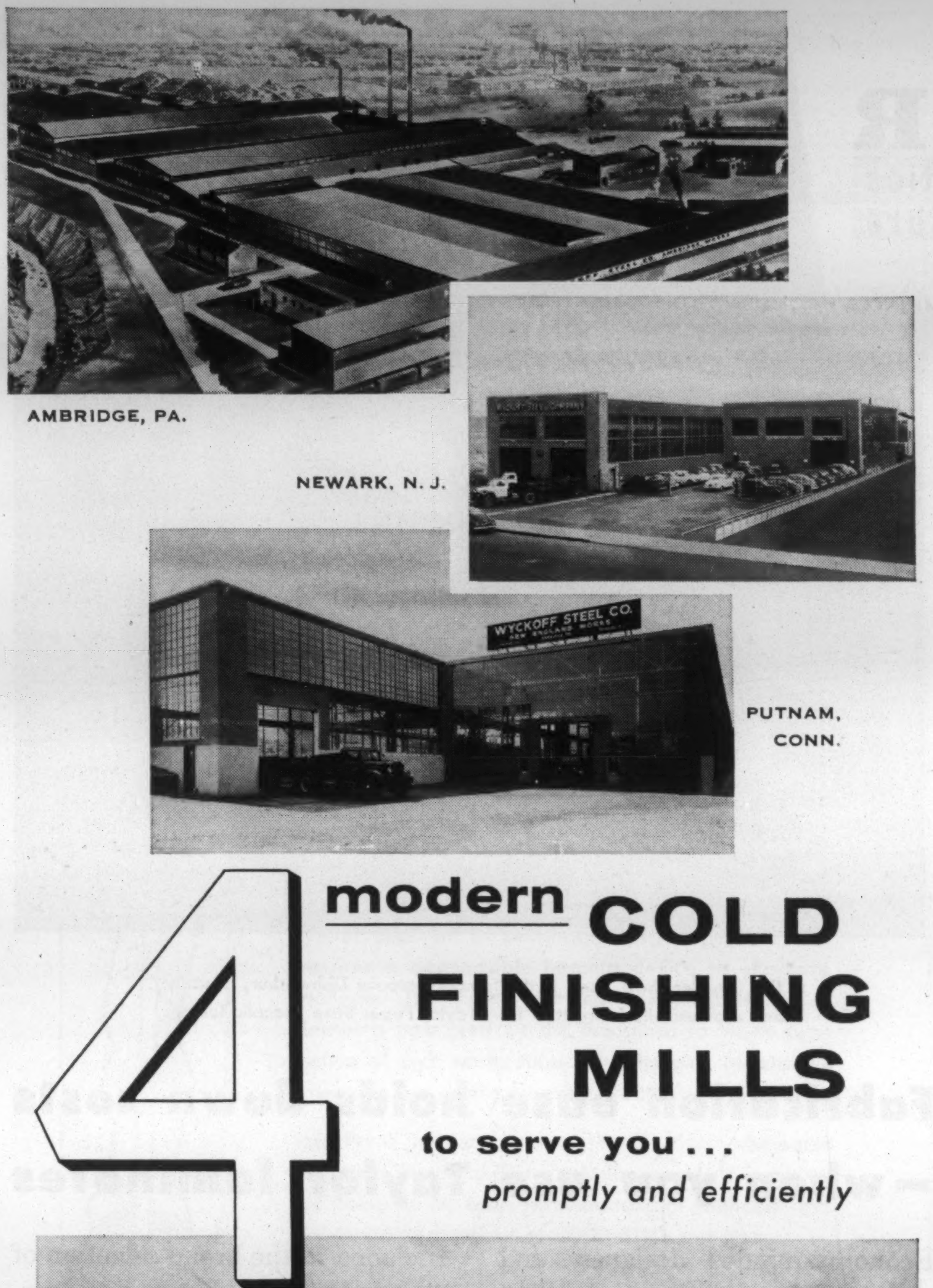

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CONTENTS NOTED

dation for 160 to 170 hr in subsequent 1800 F oxidation tests.

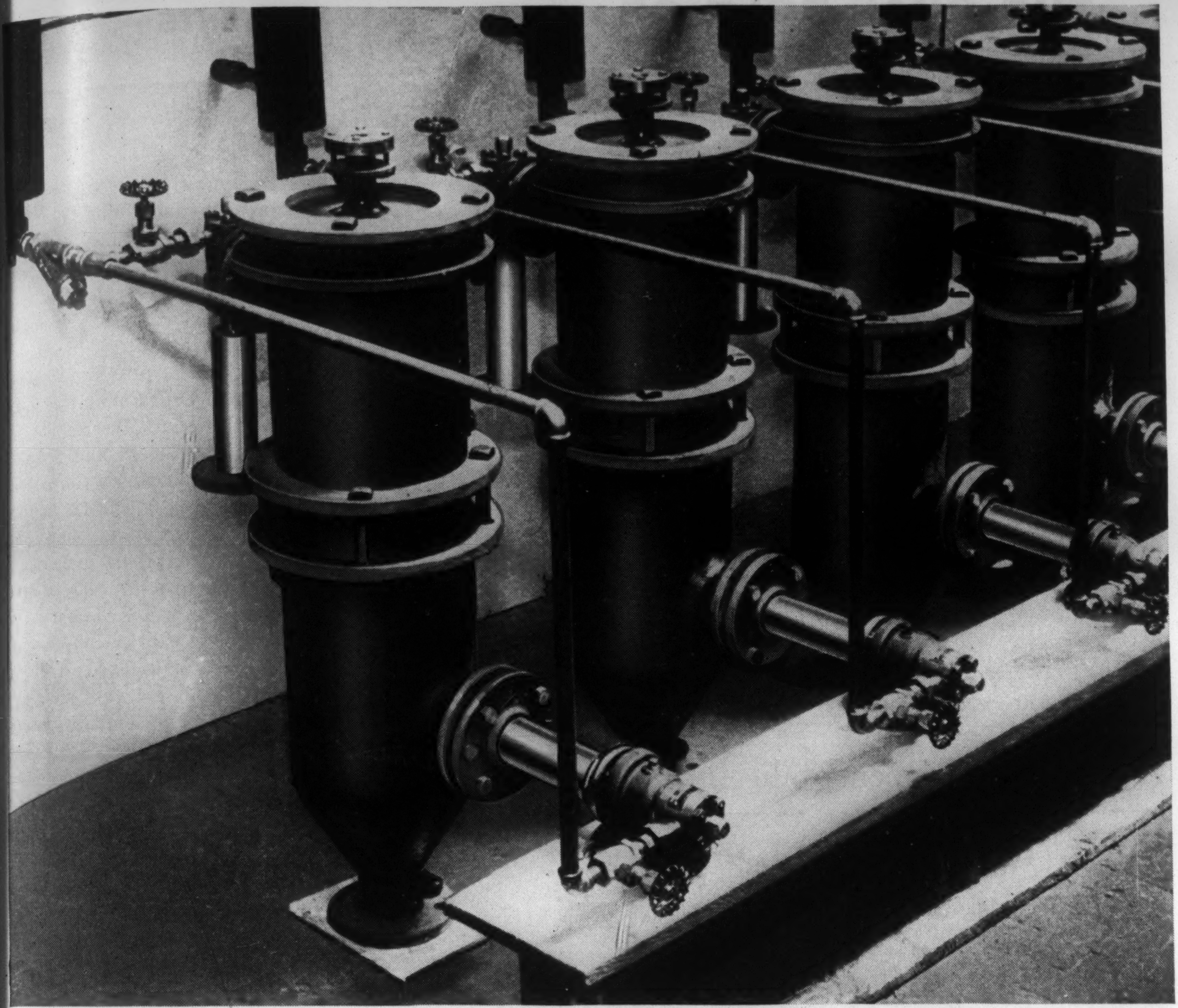
Electroplates and hot dip coatings

Electrodeposited coatings were evaluated on the basis of resistance to thermal cycling, in order to screen several modifications for possible future tests. Though none of the coatings withstood thermal cycling as well as sprayed-metal coatings, tests showed more promise for chromium than for nickel or nickel-chromium composites. Possibility of close dimensional and surface finish control justifies further tests with electrodeposited chromium.

In an effort to provide a means for coating surfaces inaccessible to the metallizing gun, tests were made with immersion coatings in a bath of aluminum-12% silicon alloy. Since three of ten specimens coated in this manner prevented oxidation of molybdenum for 500 hr at 1800 F, the coating composition seemed to hold promise. The concensus was, however, that considerable refinement in coating method was necessary to insure reliable coatings.

Creep in Reinforced Plastics Pipe

Ultimate tensile strength, popularly believed to be reliable in gaging reinforced plastics strength, is reliable only when considering products which must resist destruction for a very short time. In determining long term strength of strutural reinforced plastics, creep or cold flow is a paramount factor. Because reinforced plastics are a composite of resins and reinforcing glass fibers, it is necessary to determine which of the two component materials is most subject to creep. The resin is believed to be the weakest link of the chain. In reinforced pipe, the glass reinforcing cage is made up of continuous fibers which, ideally, should all be under equal tension. While the fibers themselves have about



Steam jet diffusers fabricated by Schutte & Koerting Company, Cornwells Heights, Pennsylvania.

TITANIUM cuts replacements 90%

These "steam jet diffusers" create a process vacuum in a large scale chemical operation. And they used to be replaced every three months.

High-velocity steam and dilute hydrochloric acid formed a natural environment for cavitation corrosion and erosion—quick death for the cast iron diffusers originally used. Several alternate corrosion-resisting materials were tried, without success, until REM-CRU titanium was specified.

The first titanium diffusers were placed in service 2½ years ago. They are still going strong, with no sign whatever of corrosion or erosion—*a 1000% improvement in service life, and more to go.*

Titanium's remarkable properties explain why such improvements are possible. First, titanium is immune to attack by chlorides—and an unusually wide spectrum of other corrosives. Furthermore, it resists erosion by high-velocity fluids—and abrasion, shock and fatigue stresses. It is as strong as steel, at about half the weight, which means significant reduction in volume—and cost—of material required.

Investigate REM-CRU titanium for yourself whenever you find too-frequent metal failures under corrosive conditions. Remember, it is available in all sizes and grades—and in substantial quantities at the lowest prices ever, thanks to REM-CRU's expanded facilities and recent price reductions. So find out more about titanium—call in a REM-CRU engineer today.

To keep abreast of the latest developments on this vital metal, write to Dept. M-2 for the Rem-Cru Review—a free periodical presenting the latest technical data on titanium alloys.

REM-CRU
TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

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THE DUAL ROLE OF

DUREZ IN INDUSTRY

DUREZ PLASTICS

add dependability in railroad signals

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put longer life in rubber soles

BOTH *could benefit your business*

One of the more fruitful sources of product betterment . . . of improved processes . . . is the phenolics developed by Durez. Their field of usefulness as molding compounds is industry-wide, firmly founded on impact strength and lustrous molded-in surface beauty. With these are combined resistance to heat and chemical action, and superior electrical properties. Employed as resins to bond, coat, or impregnate, Durez phenolics enhance wanted characteristics in other materials and increase sales values in end products.

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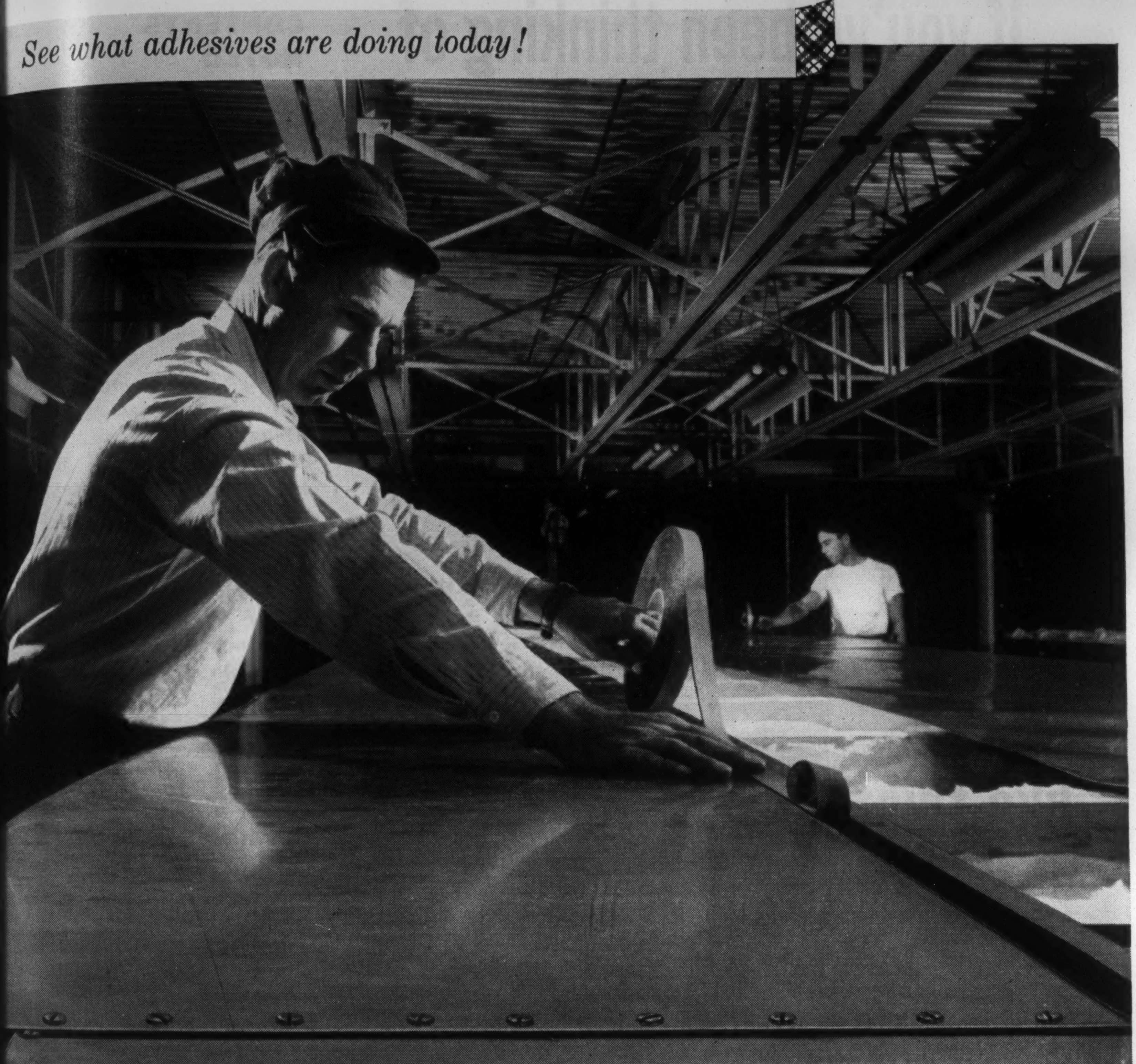
CONTENTS NOTED

a 2% elongation factor, because they are in fact under unequal tension, the reinforcing cage may require greater elongation to stress all the fibers.

These conclusions are included in a report by H. D. Boggs of Fibercast Corp., presented before a meeting of Unit Committee T-1J of the National Association of Corrosion Engineers and appearing in last November's *Corrosion*. Mr. Boggs points out 12 factors important to creep and, therefore, long term strength of reinforced plastics. Factors concerning the resin are: 1) bond between resin and glass; 2) elongation factor; 3) resin's tensile strength; 4) effect of heat on resin-to-glass bond; 5) effect of heat on resin's tensile strength; 6) shrinkage during cure and % shrink; and 7) resistance to water and chemical attack. Factors concerning the glass reinforcement are: 1) direction of reinforcement; 2) mesh openings, lay of the fiber and percentage of glass; and 3) finish and absence of foreign matter, including moisture. Factors concerning the fabrication process are: 1) cure cycle and system; and 2) expulsion of air and gas.

The resin has been found to be the central factor in long-term strength of the product. Creep studies of a given structure using various resins indicate that many resins have the same quick bursting strength, but the workable stress loads for long-term life vary greatly and in direct relation to comparative values of the resins in respect to factors listed above.

Creep studies at elevated temperatures show the weakness of many thermosetting resins. This indicates that certain distortion ratings are useless values in understanding strengths. Creep studies indicate effects of high shrink factors as no other study can. Likewise, wet strength retention or lack of retention is markedly shown through creep studies and again elevated tem-


See what adhesives are doing today!

The ribbon you see helps make this trailer home snug and weatherproof. It's an adhesive 3M Ribbon Sealer.

Fighting weather with a ribbon

Sealing weather out of trailer homes used to be a problem. Water sometimes leaked through seams, spoiling interiors, wetting insulation, corroding metal. But today this manufacturer seals all exterior lap seams with an adhesive 3M Ribbon Sealer. Since using EC 1202 he has had *no leaks* in exterior seams. This 3M product fights weather right to a standstill.

Workers easily roll this flexible, synthetic rubber ribbon along the edge of one aluminum sheet before screwing down the next. Fabric-reinforced EC-1202 is tough. It neither stretches, shrinks nor deteriorates, even during 140°F. paint drying. In fact, EC-1202 adheres so tightly it helps hold the metal together. The result—a uniform, economical, durable seal that shuts out water, dust and moisture for keeps.

Whether you face a specific problem or a general need, call upon 3M research and development. Consult your nearest 3M Field Engineer—or for literature and further information write to 3M, Dept. 62, 417 Piquette, Detroit 2, Michigan.

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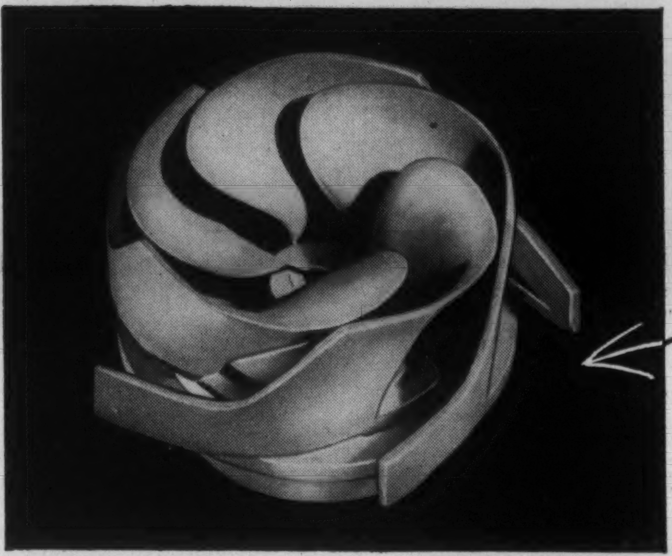
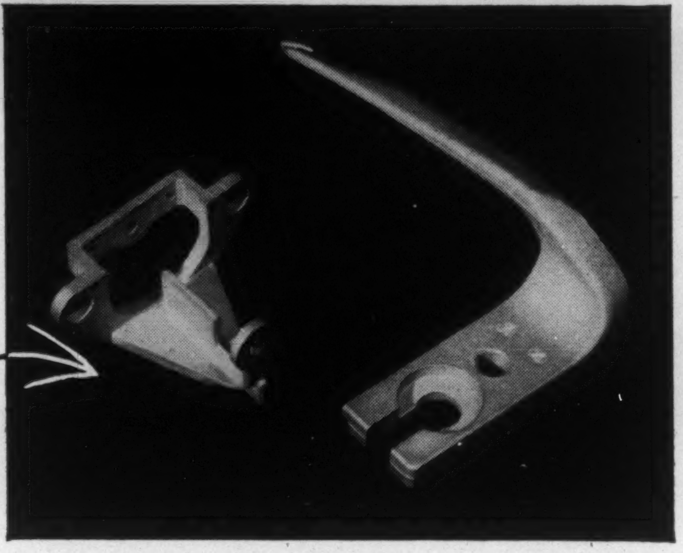
If you've been thinking of



investment castings like this

think of them also like this



● The investment casting process is, of course, especially suited for complicated parts like this impeller. We pour hundreds of these "assemblies", which could not be produced by any other means. It isn't surprising, therefore, if a designer thinks only in terms of such impossible-to-machine parts.

Actually, Precision Metalsmiths cast hundreds of parts that seem quite simple in shape. But when you get to figuring the cost of blanking, forming, machining and finishing that is eliminated in the two castings pictured here, you understand. That knitting needle, for example, needs only to be polished before it's ready for work.

Why not look over some of your drawings and let us check your costs? The book, "Pour Yourself an Assembly", describes many of these parts. For a copy, write Precision Metalsmiths, Inc., 1077 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with
PRECISION METALSMITHS INC.
INVESTMENT CASTINGS

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CONTENTS NOTED

peratures are very pointed in revealing weaknesses.

The mechanism of failure becomes a clear picture with creep study data. Three types of failure are evident, but it is suspected that there are more. The three types are:

1. *Bond failure* Elevated temperatures, far below any heat distortion points are damaging to bond strengths of many resins.
2. *Elongation failure* Most evident with brittle and highly reactive resins, it shows up in audible cracking and popping in the structure and failure in weeping at low elongation values.
3. *Low tensile strength failure* Many resins lose tensile strength at a rapid rate when a little temperature is applied. These again are temperatures far below some heat distortion points.

Ceramics Offer Wide Range of Engineering Properties

Ceramics as a class of materials offer a wide and diverse range of engineering properties. E. J. Smoke and J. H. Koenig of Rutgers define ceramics materials as those made of inorganic minerals which are usually subjected to high temperatures during fabrication. They discuss such properties as refractoriness, hardness, thermal conductivity, thermal expansion and strength in a paper delivered before The American Society of Mechanical Engineers' Diamond Jubilee Annual Meeting last November in Chicago.

Refractory properties

Probably the best known property of ceramics is their resistance to high temperatures. Melting temperatures of basic crystalline phases of most ceramic materials are quite high, starting at around 3000 F and ranging as high as 7520 F for hafnium carbide. Ceramic materials with a high glass content are available with melting points below 3000 F. Ceramics made of clinoenstatite,

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ECONOMICAL FABRICATION

Keystone adds

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High strength, high density iron and steel parts are now available in large volume from Keystone for heavy duty applications. Keystone research and development with iron and prealloyed steel powders has paced the needs for materials of high tensile strength and hardenability—enabling successful parts production for rugged service demands. Typical of these are: gears for hydraulic pumps; cams and pawls for farm machinery; power transmission gears for heavy electrical appliances, including home laundry equipment. • New possibilities for your products are presented by Keystone high strength powder metallurgy. Why not review your requirements now, and call us in for consultation?

Write for our latest publication on Powdered metal production materials — free on request.

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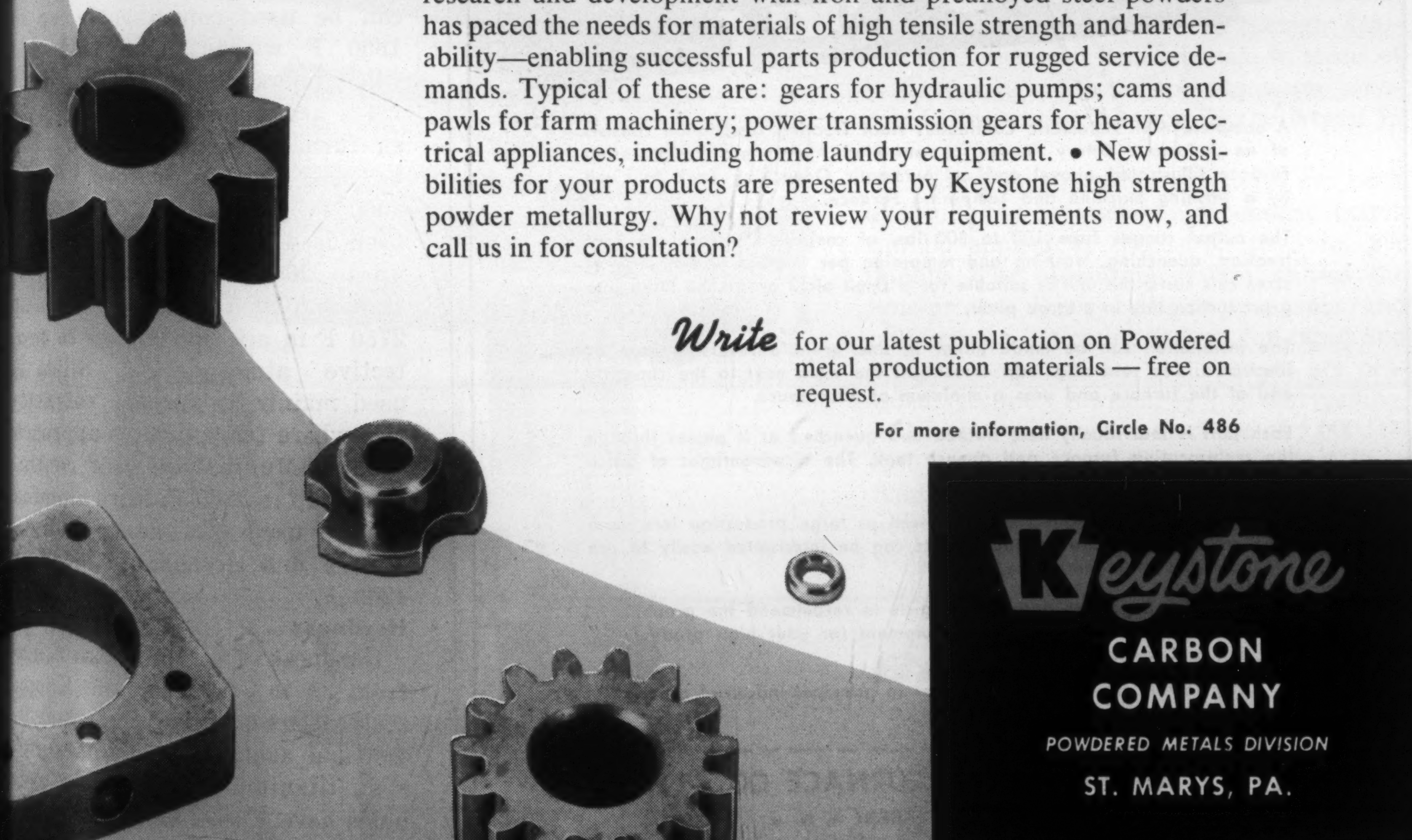
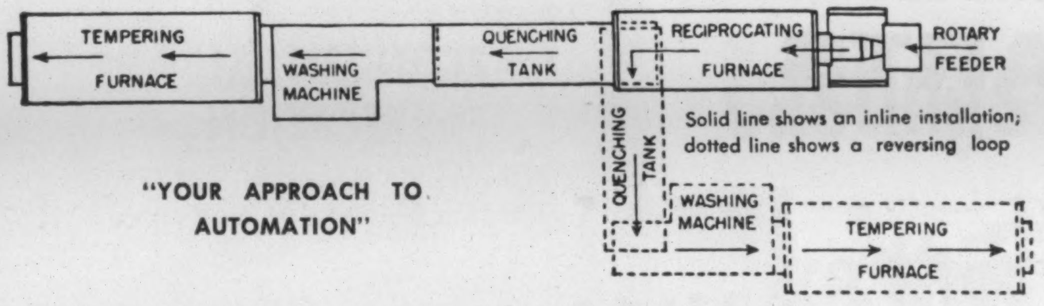
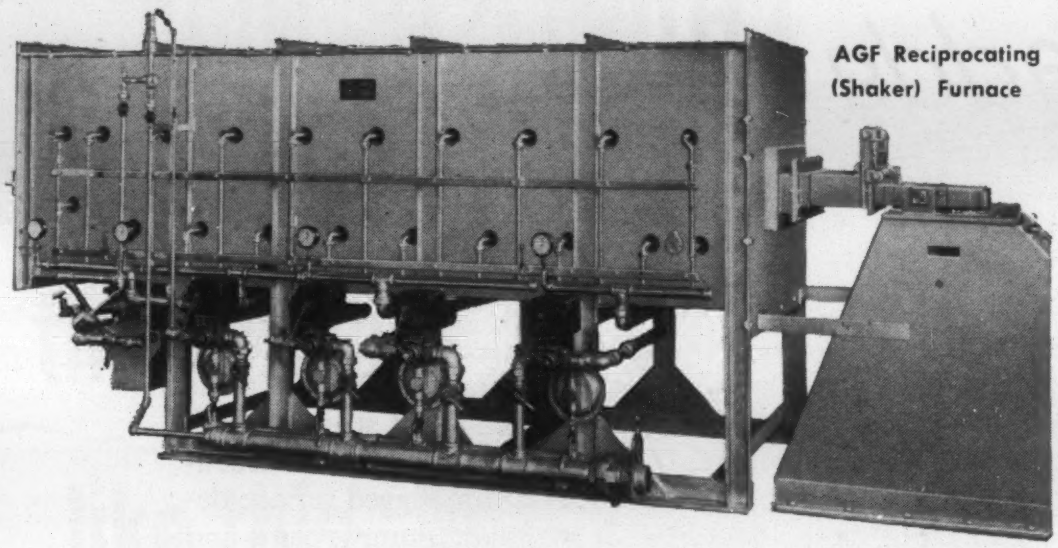


AGF Heat Treating Installation Cuts Costs



Solid line shows an inline installation; dotted line shows a reversing loop

"YOUR APPROACH TO AUTOMATION"



AGF Reciprocating (Shaker) Furnace

A complete AGF Automatic Continuous Heat Treating Installation consists of an Automatic Rotary Feeder, a controlled Atmosphere Reciprocating Furnace (illustrated above) and an Automatic Quenching Tank followed by a washing machine and Tempering Furnace.

The output ranges from 100 to 800 lbs. of controlled atmosphere heat treating, quenching, washing and tempering per hour. A wide range of sizes cuts costs; the unit is suitable for a small plant or can be fitted into a production line in a large plant.

The installation can be made either in line or in a reversing loop as illustrated. The reversing loop discharges the work next to the charging end of the furnace and uses a minimum of floor space.

Each part is individually heat treated and quenched as it passes through the reciprocating furnace and quench tank. The disadvantages of batch processing are eliminated.

Flexibility permits handling small as well as large production lots on a continuous basis. Large production lots can be interrupted easily to run small batches of urgently needed work.

Ask AGF Engineers and Metallurgists to recommend the proper AUTOMATIC HEAT TREATING Equipment for your high production and low maintenance.

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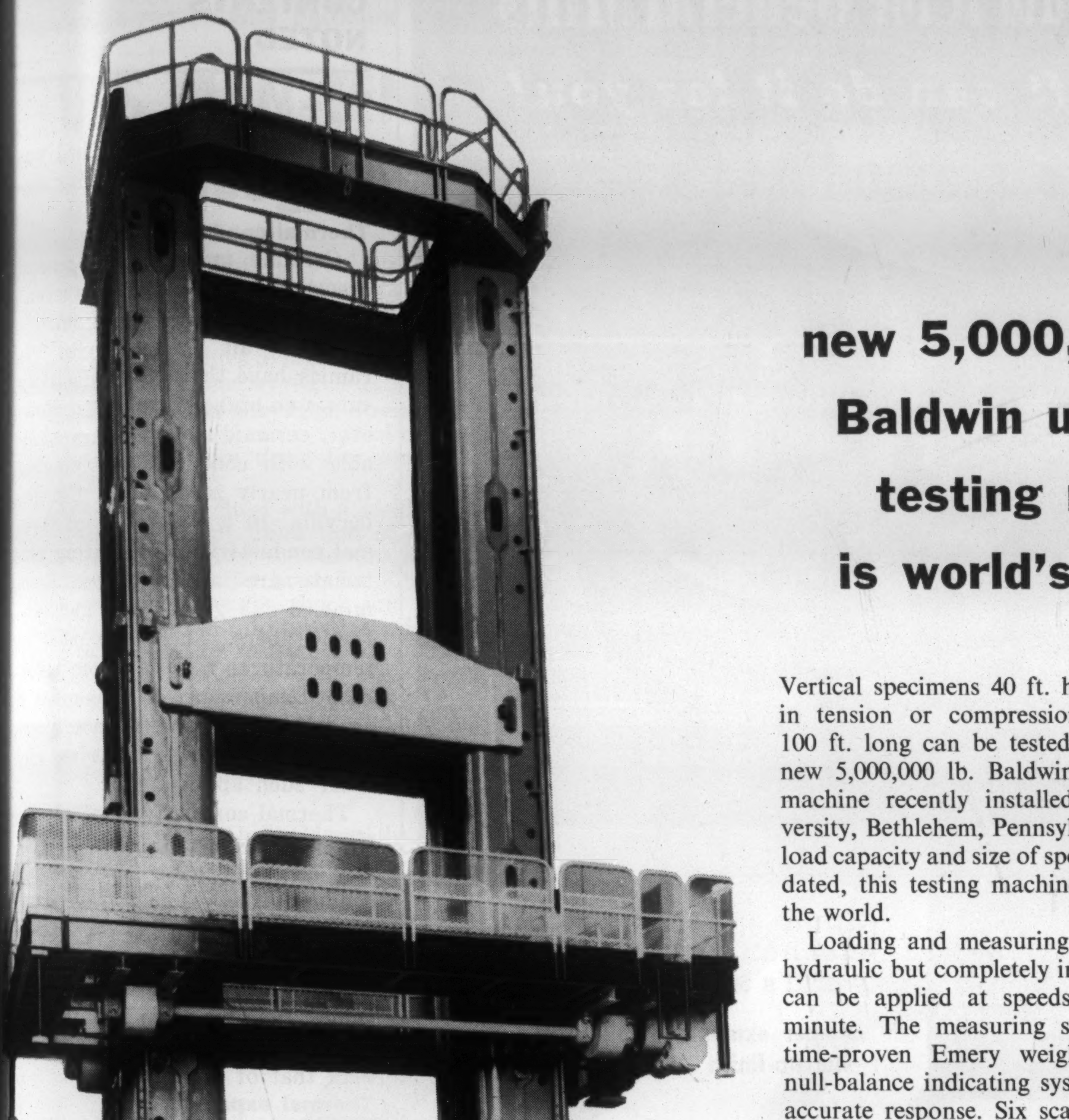
CONTENTS NOTED

titania, silica, mullite, forsterite, alumina, spinel, zircon, beryllia, zirconia, magnesia and thoria are oxide-type ceramics. All but the first two are used as refractory materials for high temperature processing. Thoria has a high melting point, but is radioactive. Silicon carbide is used as a refractory and boron carbide has a high melting temperature but is used only in special cases. Other carbides, sulfides, nitrides and borides have still higher melting points, but have been used on a very limited scale because of the rareness of some of the elements involved and difficulties in processing.

According to the authors, the best glasses can be used continuously only up to approximately 900 F. Steatite and forsterite can be used continuously up to 1800 F without distortion and when tolerances in the range of ±1% are mandatory. When used as furnace parts, forsterite can be used at temperatures up to 3000 F. Normal porcelains have been used up to 2185 F and zircon up to 2650 F. Silicone carbide stands up well at temperatures of 2750 F in air, and higher in protective atmospheres. Silica is used mainly as furnace refractories where temperatures approach 3000 F. Mullites are used continuously up to 3200 F. Pure alumina can be used continuously up to 3520 F and zirconia up to about 4200 F.

Hardness

Hardness of ceramics can range from 30 to 7000+ on the Knopp scale. Glasses range from 300 to 500 and such materials as tungsten, titanium and tantalum carbides have Knoop hardness values ranging from 1400 to 1800. Alumina, with a Knoop value of 2000 is particularly well suited for use as wear-resistant parts such as gages, bearings, thread guides and nozzles. Silicon carbide has a Knoop hardness of 2500, titanium boride 2720 and boron carbide 2800. This latter material was the hardest synthetic mate-



new 5,000,000 lb. Baldwin universal testing machine is world's largest

Vertical specimens 40 ft. high can be tested in tension or compression, and structures 100 ft. long can be tested in flexure in the new 5,000,000 lb. Baldwin universal testing machine recently installed at Lehigh University, Bethlehem, Pennsylvania. In terms of load capacity and size of specimens accommodated, this testing machine is the largest in the world.

Loading and measuring systems are both hydraulic but completely independent. Loads can be applied at speeds up to 3 in. per minute. The measuring system utilizes the time-proven Emery weighing capsule and null-balance indicating system for rapid and accurate response. Six scale ranges are provided. Accuracy is within ½% of dial reading.

Whether you need a machine of 5,000,000 lbs. or 5 lbs. capacity, you'll find it in Baldwin's complete line. For a copy of our new universal testing machines bulletin 4401, write to Testing Headquarters, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

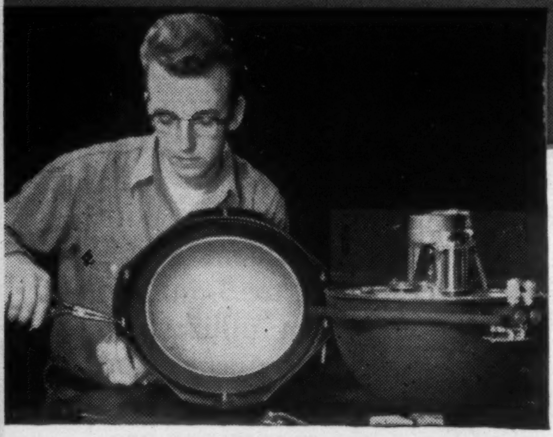
BLH BALDWIN-LIMA-HAMILTON

Divisions: Austin-Western • Eddystone • Electronics & Instrumentation • Hamilton Lima • Loewy-Hydropress • Madsen • Pelton • Standard Steel Works

For more information, turn to Reader Service Card, Circle No. 466

Spincraft did it for General Mills
Spincraft can do it for you!

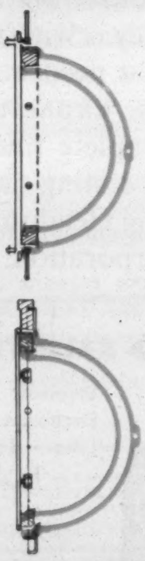
200 AIR SPEED
TAKE OFF & CLIMB
VERTICAL AC
10
100
16
SPIN
300 MPH
450
LEVEL FLIGHT-IG
WEST
2.4G
10,000
6,000



Spun spheres protect mechanical fingers of world's toughest recorder

another example of Spincraft's "start-to-finish" fabrication

15 Different Operations—
The sphere, protecting the delicate sensing instruments, is completely fabricated by Spincraft. The sphere consists of an outer steel and inner aluminum shell separated by insulating material. The two hemispheres are joined together by an ingenious locking and sealing arrangement. Spincraft's complete fabricating responsibility involved spinning, machining, arc-welding, spot welding, brazing, grinding, sawing, drilling, braking, stamping, phosphate plating, anodizing, painting, assembly and pressure testing. Craftsman (above) is shown assembling a Flight Recorder.



This aircraft Flight Recorder, manufactured by the Mechanical Division of General Mills, etches a continuous 300-hour record of heading, air speed, vertical acceleration and altitude on aluminum foil. Each Recorder is fully-enclosed and protected in a specially fabricated sphere — made by Spincraft. The recording device, when enclosed in the sphere, is designed to withstand shocks of 100G's and resist temperatures of 2000°F up to 30 minutes.

This is another example of Spincraft's versatility and manufacturing skill. We offer complete facilities for contract manufacture of finished parts, assemblies and complete products.

Take advantage of our modern tools for spinning, deep drawing and stamping as well as complete fabrication. They can pay off in savings for you.

Write for Spincraft data book. If you have a specific problem, tell us about it — no obligation.

The Spincraft Manual

WORKSHOP OF AMERICAN INDUSTRY SINCE 1919

World's largest plant fully equipped for all types of metal spinning • deep drawing • stamping • fabricating

Spincraft
SKILL WILL DO IT
INCORPORATED

See our catalog in S or write for copy

For more Information, Circle No. 382

4134 WEST STATE STREET • MILWAUKEE 8, WISCONSIN

CONTENTS NOTED

rial until recently a method was developed for manufacturing diamonds.

Thermal conductivity

Ceramic materials in general are characterized by low thermal conductivity and approximately 98% of all manufactured ceramics have thermal conductivity values no higher than 5 Btu. However, ceramic materials are available with conductivities ranging from nearly zero to 125 Btu for beryllia. In a low range of thermal conductivities, insulating materials are manufactured from mineral and glass wools and synthetic fibers. These are used at temperatures ranging from below room temperature to above 300 F as drier, oven and furnace liners and backings, pipe covering and other such applications.

Thermal conductivity of ceramics is a function of porosity. Porous ceramics have low thermal conductivities, while dense ceramics have high thermal conductivities. Thus, ceramics can be produced with thermal conductivity values ranging from that of the best thermal insulator to greater than that of aluminum.

Thermal expansion

Linear thermal expansion of ceramic materials ranges from 0.5-13 x 10^{-6} in./in./deg C between room temperature and 1300 F. Magnesia has the highest thermal expansion at 12.8. One of the prime applications for ceramics with high thermal expansion is in ceramic-to-metal seals. There are two general types of seals. The compression type uses a metal of higher thermal expansion surrounding a ceramic of lower thermal expansion, providing a vacuum-tight compression seal. The other uses metals with approximately the same thermal expansion as the ceramic.

Ceramic materials are available with much lower thermal expansions than metals. There are two types, both lithium aluminosilicates, which actually contract on heating. The beta-spodumene has a range of values from low posi-

For more information, Circle No. 377 ➤

Here's one reason why Michigan Tractor Shovels can move more yards per day, day after day . . .

USS MAN-TEN Steel provides extra strength and toughness in bucket and bucket boom

DESCRIBED AS "a bear for punishment and a hound for work" this big-yardage earth mover built by Clark Equipment Co., Construction Machinery Division, of Benton Harbor, Mich., is so engineered that every part contributes to high capacity operation and continuous, long-time service.

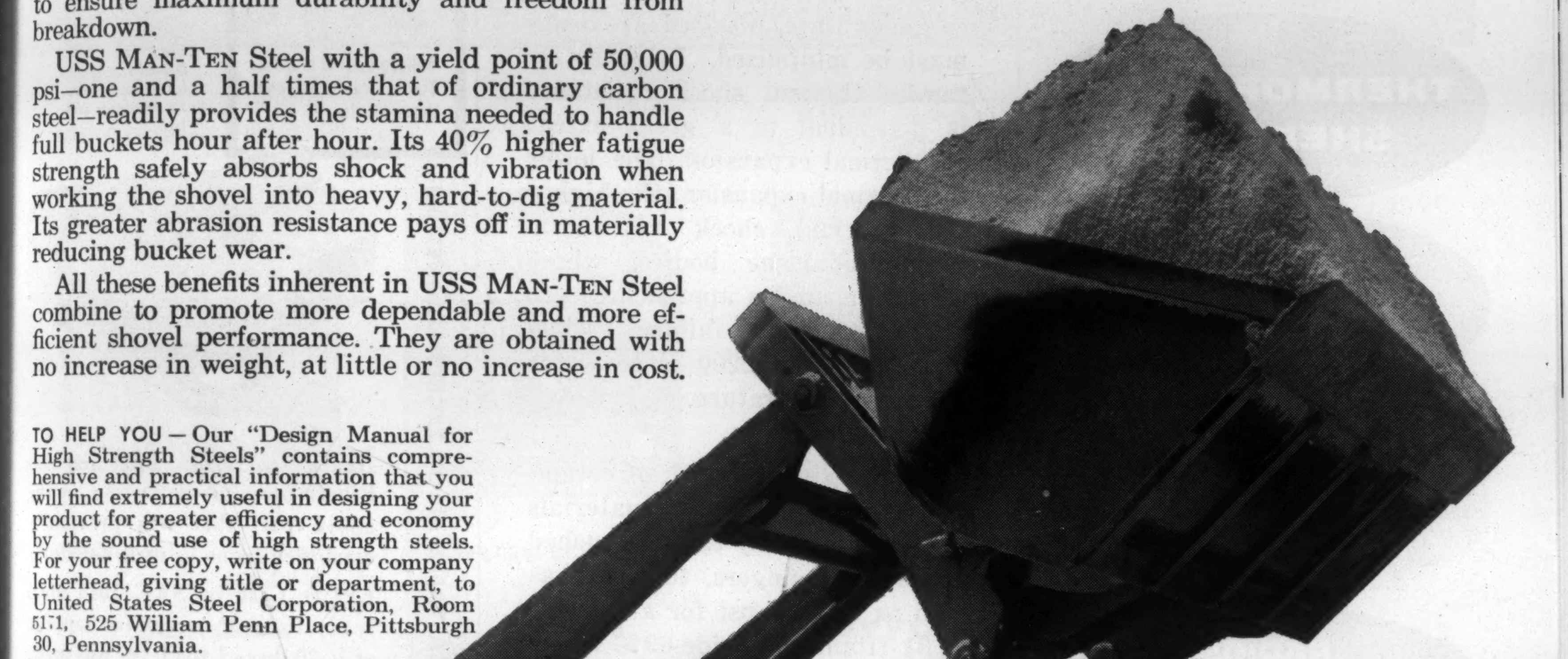
Use of USS MAN-TEN High Strength Steel in both bucket and bucket boom is typical of the care taken to ensure maximum durability and freedom from breakdown.

USS MAN-TEN Steel with a yield point of 50,000 psi—one and a half times that of ordinary carbon steel—readily provides the stamina needed to handle full buckets hour after hour. Its 40% higher fatigue strength safely absorbs shock and vibration when working the shovel into heavy, hard-to-dig material. Its greater abrasion resistance pays off in materially reducing bucket wear.

All these benefits inherent in USS MAN-TEN Steel combine to promote more dependable and more efficient shovel performance. They are obtained with no increase in weight, at little or no increase in cost.

Contact our nearest office and let us show you how you can apply USS MAN-TEN or our other High Strength Steels—USS COR-TEN and USS TRI-TEN—in place of carbon steel, to make your equipment *better*—able to do more work—able to last longer—with fewer stops for service and maintenance.

TO HELP YOU — Our "Design Manual for High Strength Steels" contains comprehensive and practical information that you will find extremely useful in designing your product for greater efficiency and economy by the sound use of high strength steels. For your free copy, write on your company letterhead, giving title or department, to United States Steel Corporation, Room 5171, 525 William Penn Place, Pittsburgh 30, Pennsylvania.



UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS MAN-TEN High Strength STEEL

6-296

UNITED STATES STEEL

More and more things are being made better . . . at lower cost, with

GOMAR

METALLIZED

THERMOPLASTIC SHEETINGS

TOYS

Gomar sheeting is being used flat, and vacuum formed in many items . . . to eliminate that costly painting or spraying operation.

TRIM

Gomar butyrate sheet has the gleaming hard finish of real metal when vacuum formed into 3-dimensional trim or trademark.

RADIOS

Speaker grilles and trim are made beautifully, and inexpensively.

DISPLAYS

Dimensional replicas of metal products—quicker, at lower cost. Flat sheeting available in 18 gorgeous metallic shades.

JEWELRY

Charming, colorful metal-like costume jewelry is being stamped and formed at minimum cost.

Send for free color chart and literature.

GOMAR
MANUFACTURING COMPANY
79 Paris St., Newark 5, New Jersey
MArket 3-1967

For more information, Circle No. 451

CONTENTS NOTED

tive to low negative. It can be made to have no contraction or expansion up to 1100 F. Beta-eucrytite is the other crystalline phase and it has a coefficient of linear thermal expansion of —5.6 x 10^{-6}. This material has not been made in the nonporous state and has found little use.

Thermal shock resistance is relatively high in most porous ceramics; however, where strong ceramics are desired porosity must be minimized. In dense ceramics thermal shock resistance is dependent to a great extent on thermal expansion. The lower the thermal expansion, the higher the thermal shock resistance. Beta - spodumene bodies, whose thermal epansion approaches zero have resisted failure when quenched from 2200 F to water at room temperature.

Strength

Compressive strength of ceramics ranges from that of materials so weak that they can be crushed between the fingers, to values as high as 600,000 psi for a mixture of 31 titanium boride-69% boron carbide, by weight. In general, for conventional ceramics, with tensile strength at unity, transverse strength is about 2 times and compressive strength is about 8 to 10 times tensile strength.

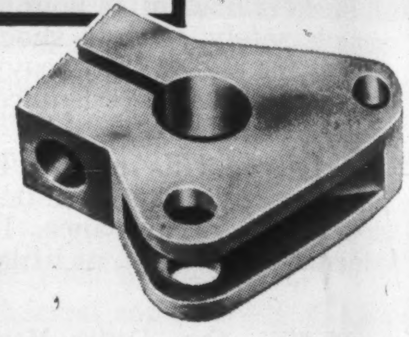
Beryllia is an extremely strong ceramic with a compressive strength of 188,000 psi and transverse strength of 35,000 psi. Steatite, forsterite and zircon ceramics have compressive strengths ranging between 75,000 and 90,000 psi. Porcelain, glass-bonded mica and cordierite have lower compressive strengths in the range of 35,000 to 50,000 psi.

Other properties which the authors point out as important in ceramic materials are electrical properties ranging from insulators through semi-conductors to conductors; ferroelectric and antiferroelectric, piezoelectric and ferromagnetic characteristics; and excellent chemical durability.

(More Contents Noted on p. 196)

MACK TRUCK
Specifies EpCo
INVESTMENT CASTING
for Vital Part

Bulldog Symbol of Mack Trucks Sturdiness and Dependability



"EPCO Cast lever used by Mack Diesel trucks and buses on hydraulic governor control."

INVESTMENT CASTINGS IN ANY CASTABLE ALLOY EXCEPT MAGNESIUM

Mack engineers specified an EPCO Investment Casting on the above part that was previously machined from ½ inch flat stock.

EPCO Cast in SAE 1045 steel ready for use except for tapping of ¼-20 thread, the lever was made at less cost and well within Mack's high quality standards.

EPCO Cast levers have been in constant use since 1947, and have performed with the same rugged dependability expected in a Mack Bus or Truck.

Get an EPCO quotation before machining or assembling your intricate parts.

Ask about our Vacuum Casting Process for increased quality control

EpCo
ENGINEERED PRECISION CASTING CO.

N. J. HIGHWAY 79
MORGANVILLE, N. J.

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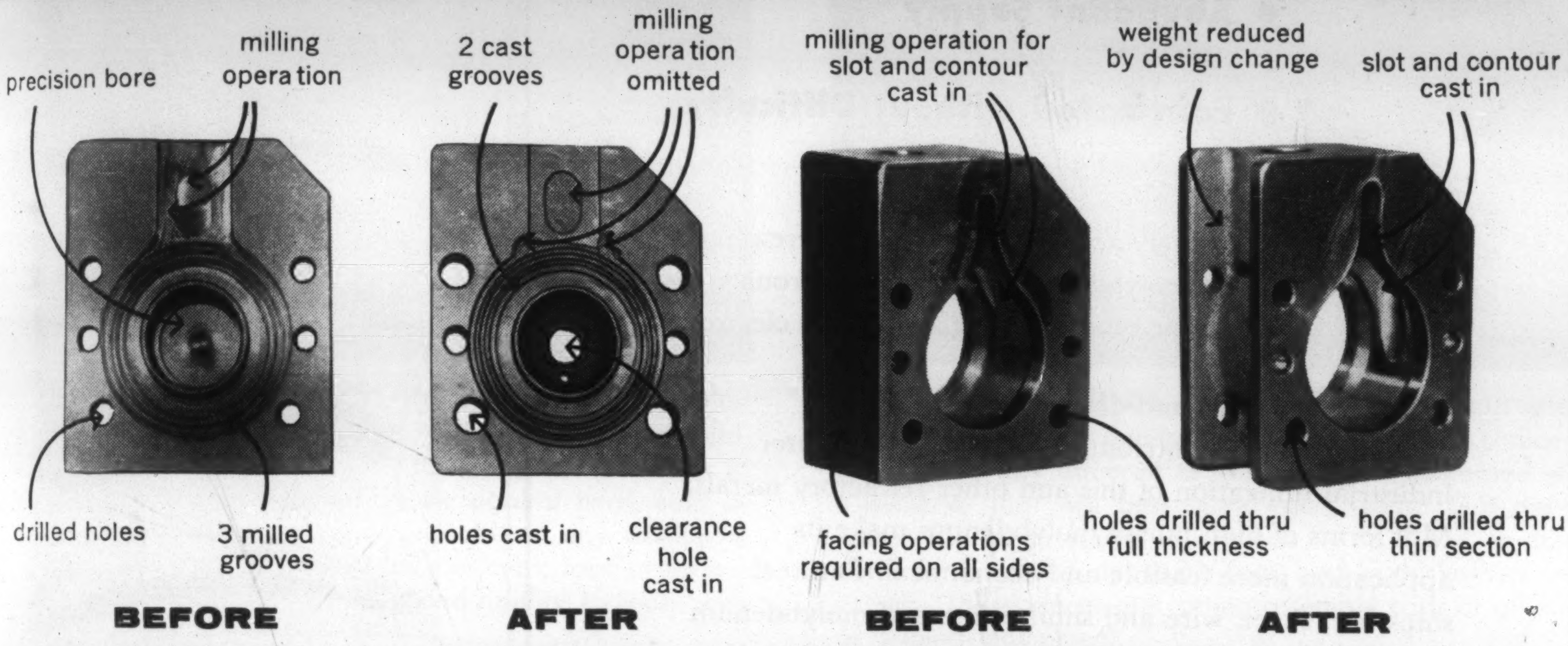
In casting pump parts
AKH* *makes the difference*

*** Advanced Know-How**


precision bore
milling operation
2 cast grooves
milling operation omitted
milling operation for slot and contour cast in
weight reduced by design change
slot and contour cast in
drilled holes
3 milled grooves
holes cast in
clearance hole cast in
facing operations required on all sides
holes drilled thru full thickness
holes drilled thru thin section
BEFORE
AFTER
BEFORE
AFTER

Machining time on the stainless steel housing for the Vanton "flex-i-liner" pump was cut from 14 hours down to 2 through the use of shell cores; weight was reduced and drilling simplified through casting redesign; and the use of shellcast eliminated the milling on the end plates, making it economical to produce them in stainless steel instead of aluminum. This resulted in a better product in less time and for less money thanks to Cooper Alloy *Advanced* Know-How.

For full details on this specific application write for free copy of case study #2.

COOPER ALLOY
CORPORATION • HILLSIDE, N. J.

Foundry Products Division

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The Characteristics of

MOLYBDENUM

- **Strong at High Temperatures**
- **Excellent Electrical Properties**
- **Abundant Supply**
- **Fabricated without Difficulty**

. . . largely account for the ever-increasing use of molybdenum in everything from electronic tube parts to glass furnace electrodes.

Fansteel's research and development in powder metallurgy have contributed much to the greater industrial utilization of this and other refractory metals. Mill forms of high purity molybdenum make its application more feasible and economical. Fansteel ships bar, sheet, wire and similar forms of molybdenum for countless industrial uses.

In addition Fansteel maintains modern facilities for part and product fabrication—forming, stamping, bending, deep drawing, forging, machining, brazing, welding, assembling, finishing—according to customer specification.

Fansteel engineers can assist you in the design and fabrication of molybdenum components. Their recommendations regarding refractory metals are yours for the asking.

"Fansteel Metallurgy", a journal devoted to refractory metals, will be sent to you upon receipt of your name and address.

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U.S.A.

K552A

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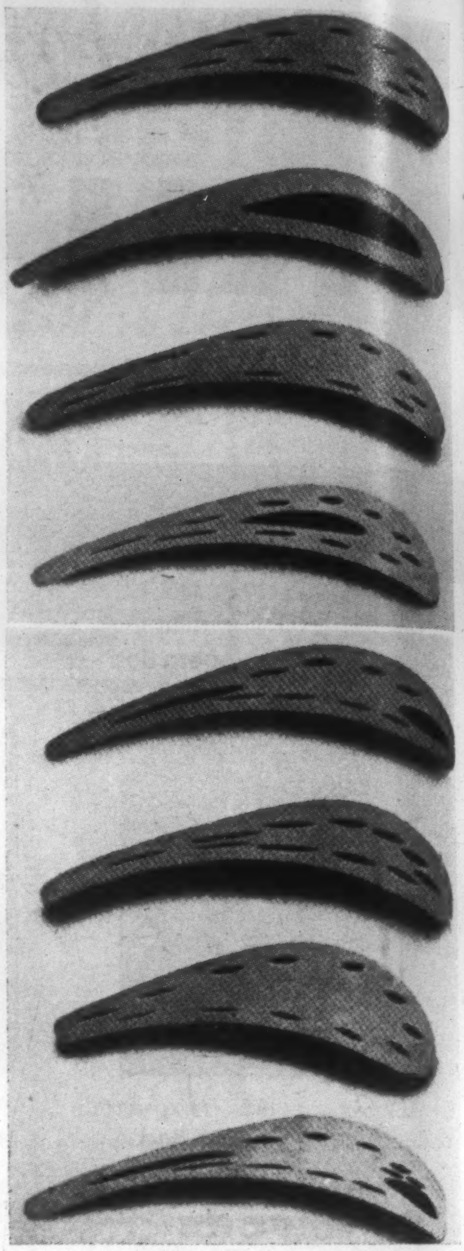


New Shapes in Hot Extruded Steel

Hollow gas turbine blades and blades with cooling channels of various forms have been produced in nickel-base Nimonic type alloys by an interesting new technique. The technique is applied to the Ugine-Sejournet process of hot extrusion using a glass lubricant. Results of the technique were reported by M. Ballay of the Nickel Information Center in last October's *La Technique Moderne* (French). Before extrusion, billets are bored with appropriately placed holes, which are then filled with a special material. After extrusion the bars are cut to required size and the filling substance removed. As yet, extruded bars of this type have been used mainly for nozzle blades, but their use is expected to extend to movable turbine buckets.

(More Contents Noted on p. 198)

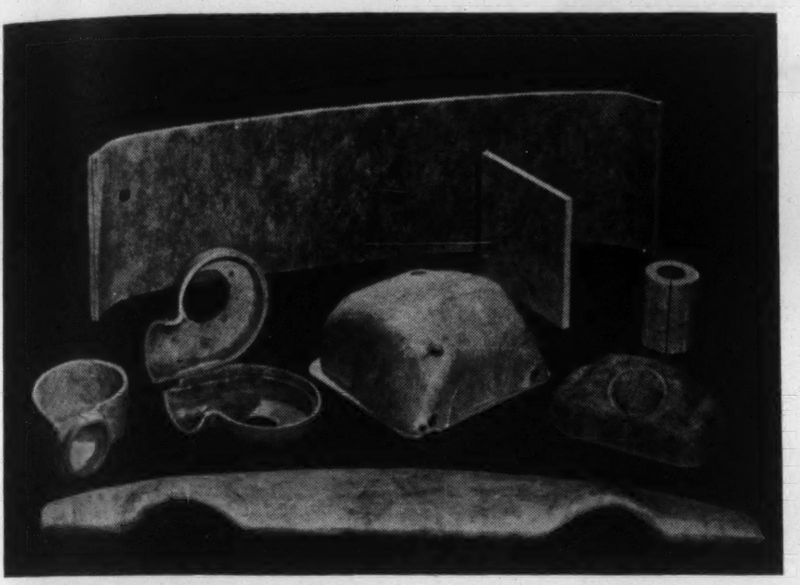
GLASS FIBER INSULATION

. . . any way you like it!

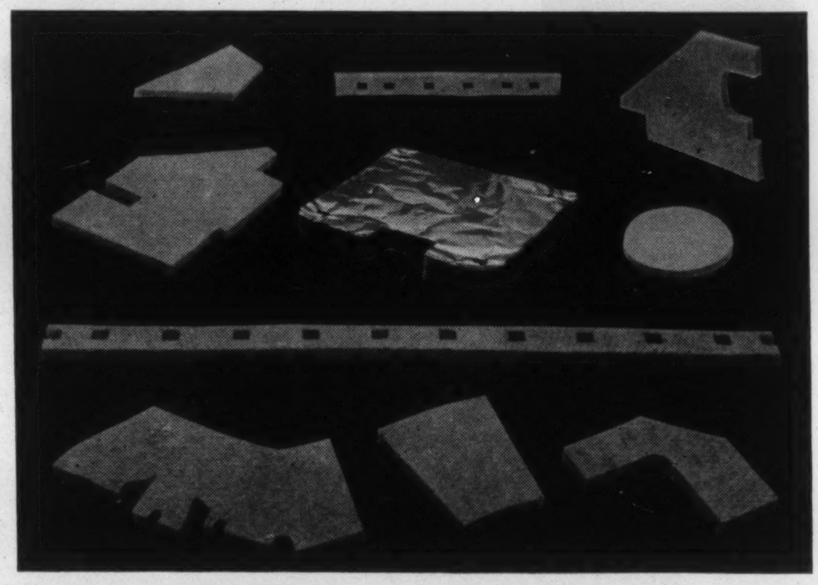
Only Gustin-Bacon has the specialized facilities and service to supply you with glass fiber insulation, any way you want it — die-cut . . . molded . . . in cylinders . . . in rolls . . . with or without a variety of facings and special coatings.

G-B production and shipping personnel are trained to help manufacturers of O.E.M. equipment meet rigid production schedules. You name the time and place; Gustin-Bacon will ship these unique glass fiber products *direct from the factory* to your assembly line!

Give you an idea? Send us a drawing or freehand sketch . . . a rough estimate of quantity . . . tell us the end use — and our design engineers will work out your idea, without cost or obligation.

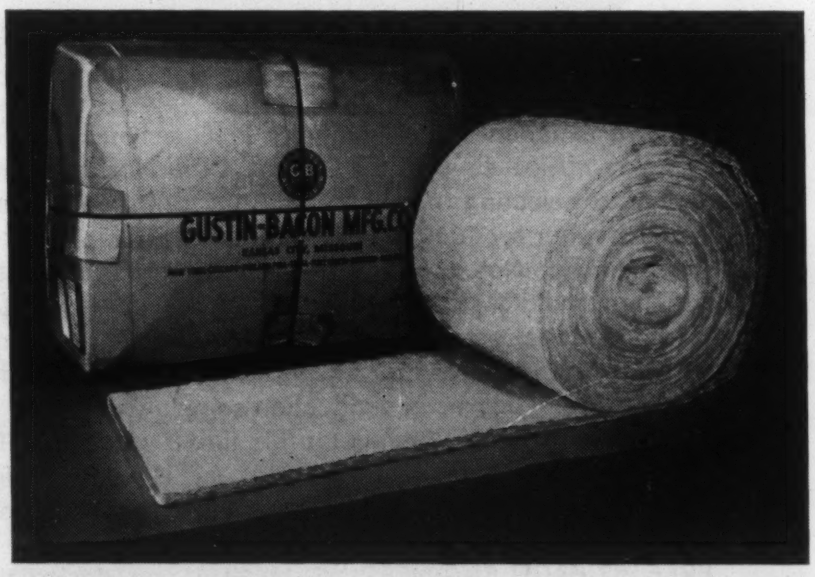


SOFT MOLDED PARTS. Molded-to-shape insulation represents an entirely new concept in the insulation field, and enables manufacturers of assembly-line products to insulate faster and more efficiently against heat, cold or sound. G-B molded parts are available in any size up to 8′ x 10′, in densities from 2-10 lbs. per cubic foot, in various thicknesses from ⅛″ up. Firmness and rigidity increase with density.



DIE-CUT MATERIAL. Gustin-Bacon die-cut glass fiber insulations are available plain or with your choice of facings, already adhered to the insulation, or coated with a material that will best serve your needs. G-B die-cut pieces can be produced in any size up to 5′ x 6′, in densities from ¾ - 3 lbs. per cubic foot, and in thicknesses from ½″ up. These pieces are cutting assembly costs of all kinds of original equipment.

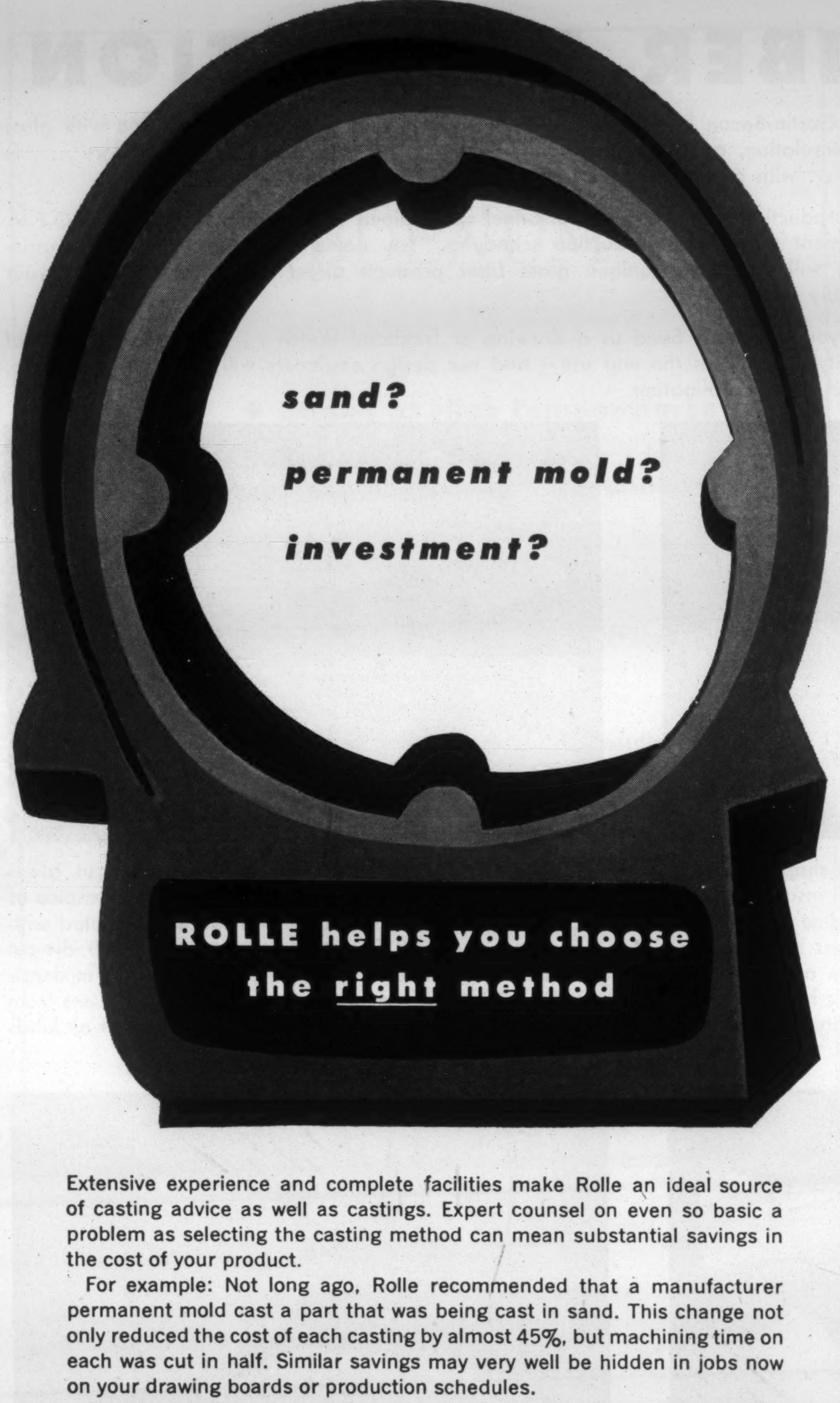
CYLINDRICAL MOLDED PARTS. In wide use as pipe insulation, G-B one-piece molded cylinders of fine glass fibers are going into O.E.M. equipment too. Available in inside diameters from ¾″-24″ . . . in various wall thicknesses . . . in lengths up to 6′ . . . *with* or *without* a slit seam. Also available with facings and airtight interior coatings for special uses, such as air ducts.



BLANKET ROLLS. Gustin-Bacon offers blanket-roll insulation of both fine blown fibers, and long, textile-type fibers. Both are available in a wide variety of roll lengths, widths and thicknesses. They are available plain or with a choice of facings — some for appearance, some for light dissemination, some for vapor barriers. G-B blanket rolls can also be coated (e.g., vinyl spray coated).

GUSTIN-BACON MANUFACTURING CO.
234 W. 10th Street, Kansas City, Mo.

For more information, turn to Reader Service Card, Circle No. 332


sand?
permanent mold?
investment?
ROLLE helps you choose the right method

Extensive experience and complete facilities make Rolle an ideal source of casting advice as well as castings. Expert counsel on even so basic a problem as selecting the casting method can mean substantial savings in the cost of your product.

For example: Not long ago, Rolle recommended that a manufacturer permanent mold cast a part that was being cast in sand. This change not only reduced the cost of each casting by almost 45%, but machining time on each was cut in half. Similar savings may very well be hidden in jobs now on your drawing boards or production schedules.

Any wonder so many manufacturers find it wise to call Rolle in for advice whenever an aluminum or magnesium part is in the design stage? There's no chance of error or bias, for Rolle offers sand, permanent mold, and investment casting techniques.

FREE 57-PAGE ENGINEERING MANUAL on designing aluminum and magnesium alloy castings available on letterhead request. Write now for your personal copy.

for complete foundry service **ROLLE**

MANUFACTURING COMPANY

303 Cannon Avenue, Lansdale, Pa. • Lansdale 5162

An entirely new method for extrusion molding will be presented by Rolle in the near future. Write now to receive complete information as released.

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CONTENTS NOTED

Tin Alloys Vs Nickel-Chromium For Protective Coatings

Recent tests have been carried out by the Tin Research Institute to determine the feasibility of using tin-nickel alloys or chromium plated over a tin-bronze deposit to replace nickel-chromium decorative finishes. The tests were stimulated by the strategic importance of nickel and some dissatisfaction with performance of nickel-chromium coatings. The institute found that substitution of part of the nickel layer in nickel-chromium coatings by a layer of tin-bronze holds promise of reducing pore corrosion, but it seems that substitution must stay short of 100%. Tin-nickel also proved to be fully as resistant to tarnish and corrosion in the atmosphere as chromium. In positions sheltered from rain, tin-nickel coatings retain brilliance better than nickel-chromium. Results of the investigation were reported by S. C. Britton in last October's *Tin and Its Uses* (British).

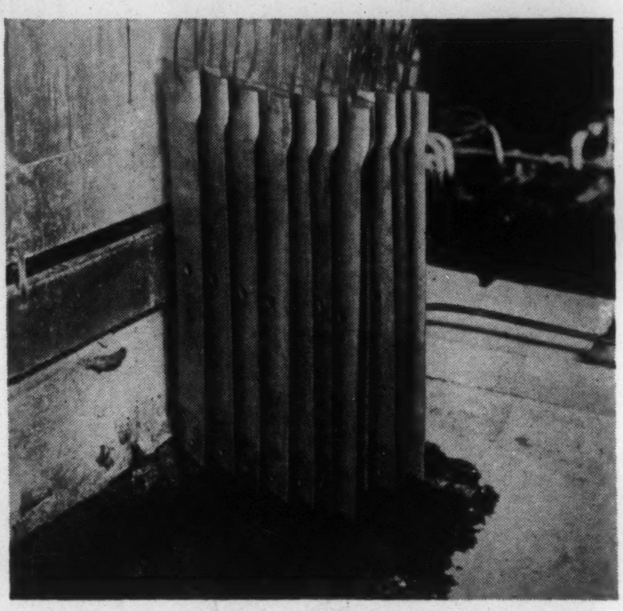
Test results

Coatings in which chromium was applied directly over bronze deposits were not very satisfactory. Corrosion of steel at pores in the coating was slight, but adhesion of chromium to bronze was not good, and cracking and local peeling occurred after exposure. A nickel layer, 0.0002 in. thick, between bronze and chromium gave some improvement, but during full exposure to weather a light brown discoloration appeared. Coatings in which 0.0006 in. of bronze were followed by a similar thickness of nickel produced satisfactory results. This type of coating and ones in which 0.0002 in. of bronze was followed by 0.0001 in. of nickel showed much less rusting at pores than coatings of chromium over nickel alone. Pore rusting was less for the bronze-nickel-chromium coatings of total thickness of 0.0012

GENUINE
LAWN-BOY
MOWER BLADE
PART NO. 602797

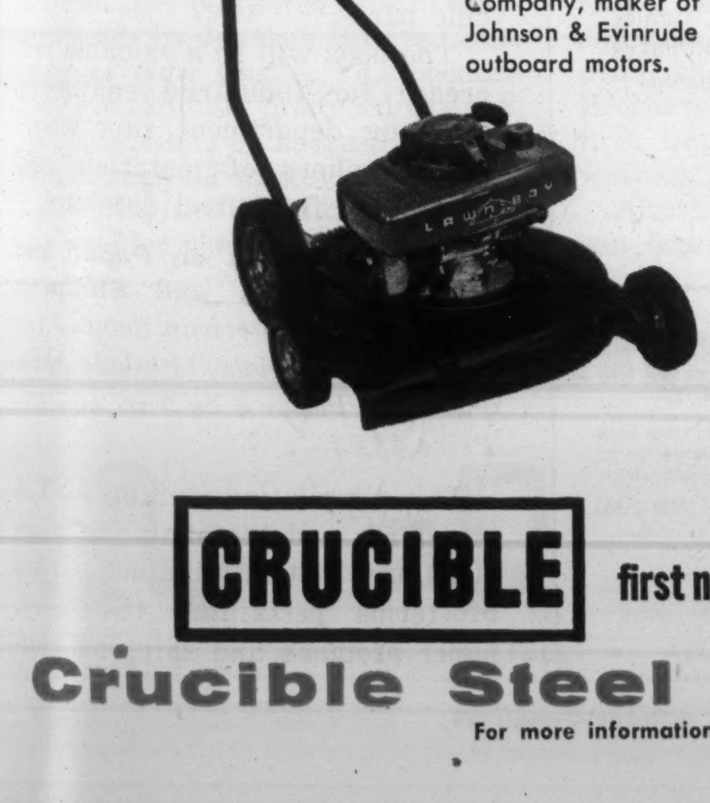
Cutter blade of Crucible alloy steel.

First step in manufacture of cutter blade. Crucible beveled blade alloy steel is fed through this 100-ton press, where it is cut to length and holes punched.



Next, lengths are formed to shape on a hydraulic press, and then given a tempering bath as shown.

CRUCIBLE ALLOY STEEL *cuts blade damage in rotary mowers . . .*



Lawn-Boy mower. Built by RPM Manufacturing Co., Lamar, Mo., a subsidiary of Outboard, Marine & Manufacturing Company, maker of Johnson & Evinrude outboard motors.

Rotary lawnmower cutter blades, whirling at high speeds, often hit small rocks or bits of trash. Ordinary steels just can't take that sort of rugged treatment. They chip, crack — wear out far too quickly. That's why in leading mowers, like the new *Lawn-Boy*, you'll find special *alloy* steel cutter blades *designed for reliable performance.*

For Crucible has developed a *special alloy steel* made to give the best possible combination of toughness and hardness for long-lasting edges—and formability and ductility for ease of manufacture. It's been so successful that *Crucible is now the largest producer of lawnmower steels.*

Most Crucible steels are designed to fill *special* needs. If you have an application where ordinary steels won't do, come to Crucible. Take advantage, too, of the dozens of technical booklets and data sheets Crucible has prepared to help you make the best use of special steels. For a free publication catalog, write *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 427

New wood-plastic laminate is easy to work, extremely flat, rigid, remarkably stable . . .

HOW CAN YOU USE VERSATILE NEW NOVOPLY?

Nothing like Novoply. Novoply is a 3-ply laminate composed of faces of specially prepared wood flakes and a core of wood chips – all resin-impregnated, and molded under heat and pressure into an extremely dense, hard, flat panel.

Novoply plus features. Novoply has tremendous mechanical strength. Because of its 3-ply construction and high water-resistance it is extremely flat and warp-resistant. Dimensional stability is unusual in *all* directions—*less than 0.3%* expansion and contraction even in the presence of extreme humidity. It glues readily and works easily on modern high-speed equipment.

Make it better with Novoply. Some current uses: core stock for high pressure laminates such as Micarta®, store fixture cabinets, cores for veneered furniture, practically warp-free sliding doors, wall paneling, counter fronts. Get your free sample and data book and see what Novoply suggests to you.

1. Novoply surface is remarkably flat, and its mosaic-textured look makes it a handsome panel for decorative use. **2.** Top and bottom surface plies are precision-made wood flakes. **3.** Center ply is of specially graded wood chips. Both flakes and chips are resin-coated and -impregnated.

NOVOPLY PANEL SPECIFICATIONS: THICKNESS: ¾"; **SIZES:** 24" x 72", 24" x 96", 30" x 48", 30" x 60", 30" x 72", 36" x 72", 48" x 48", 48" x 72", 48" x 84", 48" x 96", 48" x 120", 48" x 144"; also cut-to-size for volume users from panels 6' x 12' and 4' x 16'. Available in ⅜", ⅝", 1¹⁄₁₆", 1" thicknesses, sizes 48" x 96", and other sizes. **IMPORTANT NOTE:** Only slight extra cost for long-length Novoply panels up to 16'.

NOVOPLY®
by Weldwood®
A product of
United States Plywood Corporation
Weldwood—The Best Known Name in Plywood
87 Distributing Units in Principal Cities

UNITED STATES PLYWOOD CORPORATION
Weldwood Building
55 West 44th Street, New York 36, N. Y.

RUSH my free sample of Novoply, and engineering data booklet detailing results of Novoply tests conducted by a famous independent research and testing laboratory.

(MM-2-56)

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COMPANY......................................
ADDRESS......................................
CITY.......................STATE...........

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in. than for nickel-chromium coatings of total thickness of 0.0016 in.

Tin-nickel, whether applied directly to steel or over undercoatings of copper or bronze remained bright although a few rust spots appeared at pores. Variation of undercoat thickness seemed to have little effect.

The author also points out that no evidence was found in support of the complaint that tin-nickel may look dirty more quickly than chromium. It was found that any such effect must be confined to environments such as atmospheres heavily laden with dust or soot accompanied by frequent rain-fall.

BOOKS

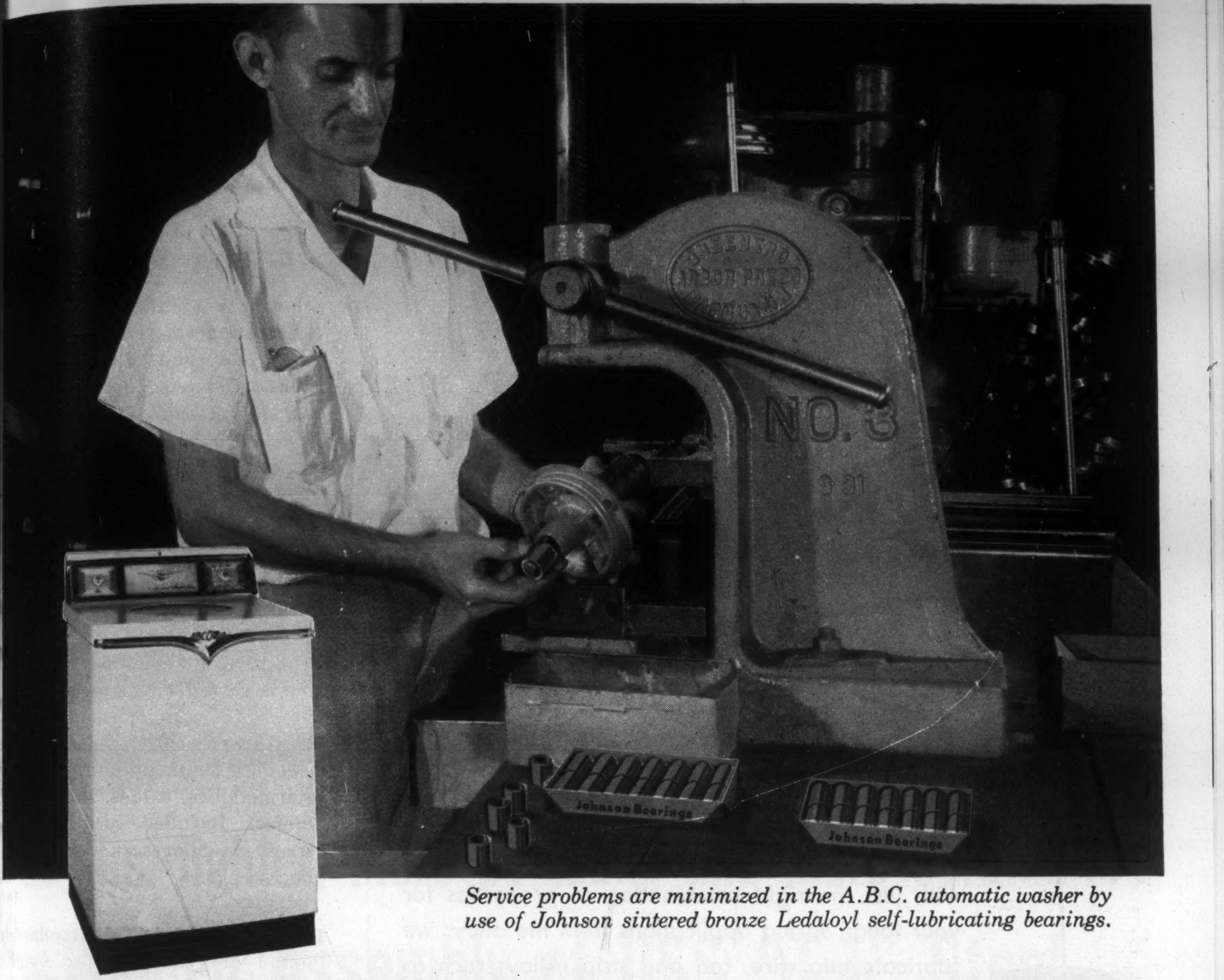
Handbook of Barrel Finishing. *Ralph F. Enyedy. Reinhold Publishing Corp., New York 22, N.Y. 1955. Cloth 6 by 9 in. 255 pp. Price $7.50.*

This book, the first dealing exclusively with barrel finishing, covers the process from cleaning to coloring, polishing and burnishing. It contains 19 chapters on equipment, cleaning with sawdust, tumbling with or without chips or grinding forms, types of tumbling applicable to various parts, and applications. Case histories illustrate the procedures recommended for finishing more than 150 specific parts.

The book will be a valuable reference for industrial engineers, finishing department supervisors and suppliers of materials and equipment for barrel finishing.

ASTM Standards on Paper and Paper Products and Shipping Containers. *American Society for Testing Materials, Philadelphia, Pa. 1955. Paper 6 by 9 in. 406 pp. Price $3.75.*

This compilation contains ASTM standards and tentative specifications, test methods and definitions of terms pertaining to paper, paper products and shipping con-



Service problems are minimized in the A.B.C. automatic washer by use of Johnson sintered bronze Ledaloyl self-lubricating bearings.

Altorfer Brothers Company assures customer satisfaction by using Johnson Bearings in its A.B.C. Washers

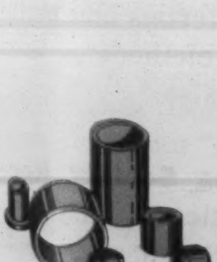
One way that Altorfer Brothers Company, Peoria, Ill., manufacturer of the A.B.C. line of washers, ironers and driers, gets assurance of customer satisfaction is to install the finest bronze bearings available. Altorfer uses powdered bronze bearings made by Johnson Bronze Company of New Castle, Pa., because they are carefully produced to exact specifications and because they retain enough oil to service the bearings during the life of the washer.

Consider the Ledaloyl sintered bronze bearings which Johnson Bronze makes for use on the A.B.C.-O-Matic washer's shaft and tube. This bearing, one of eight sintered bronze bearings, is the workhorse of the washer and is vital to the operation of the shaft which spins the tub. Johnson Bronze Company has supplied these bearings to Altorfer Brothers since 1950 when the firm first began to make automatic washers.

Altorfer Brothers has used Johnson bearings for other applications since 1928 because of their uniform high quality.

If you have a tough application that calls for long bearing life under rugged conditions, you will want to learn how Johnson Bronze bearings can build more customer satisfaction into your product. If you need it, trained engineering help is available to guide you in choosing the bearings which will lower costs and improve performance. Johnson Bronze Company, 769 South Mill Street, New Castle, Pa.

Johnson Bearings



LEDALOYL (powder metallurgy)

• BRONZE ON STEEL

• ALUMINUM ON STEEL

• CAST BRONZE

• STEEL AND BABBITT

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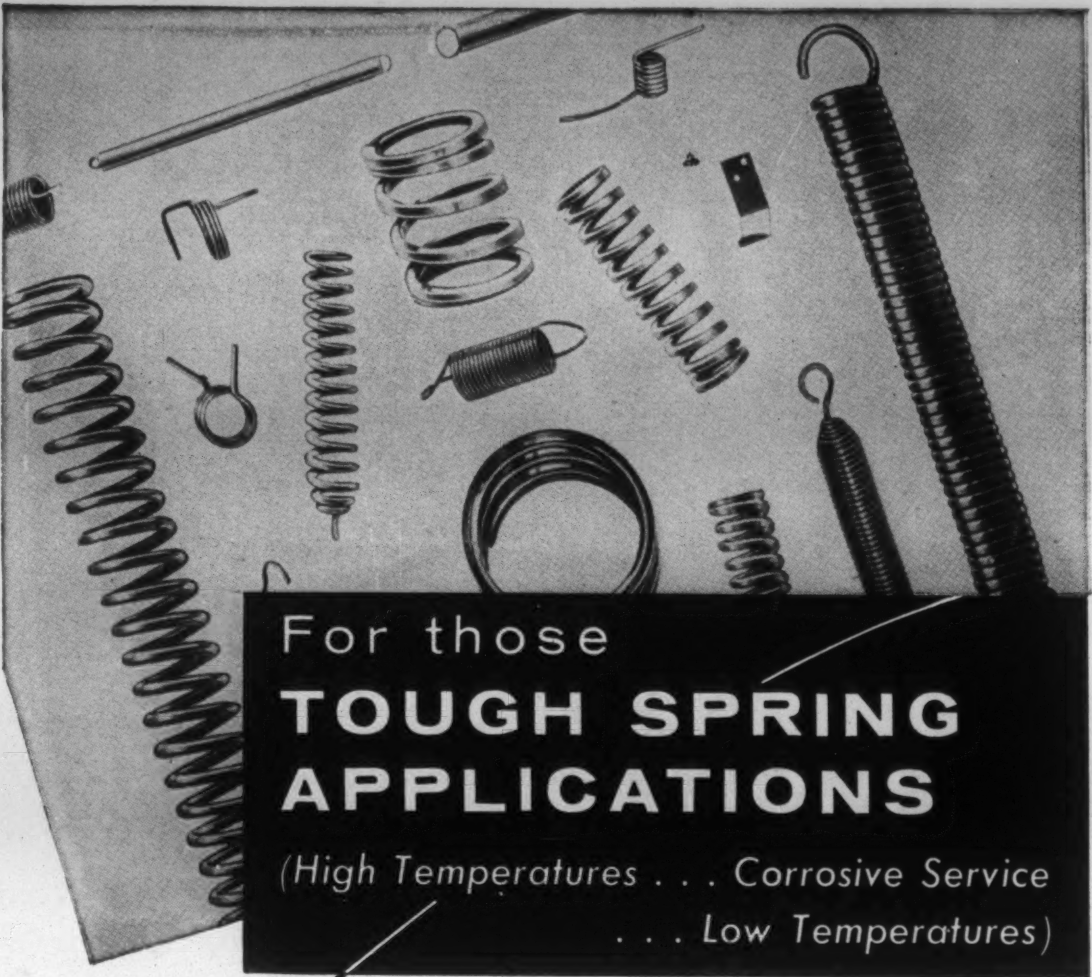
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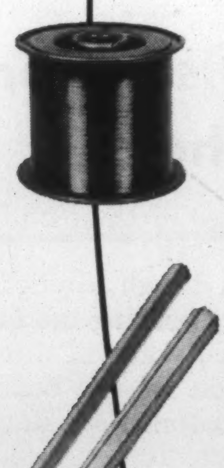

CONTENTS NOTED

BOOKS

tainers. Included are a total of 101 designations including 5 new standards and 10 which have been revised since the previous edition.

Abstracts of the Literature on Semiconducting and Luminescent Materials and Their Applications. *Compiled by Battelle Memorial Institute. John Wiley & Sons, Inc., New York, N. Y. 1955. Paper $8\frac{1}{2}$ by 11 in. 200 pp. Price $5.00.*

This complication of literature abstracts, sponsored by The Electrochemical Society, covers domestic publications for the calendar year 1954 and foreign from about Sept 1953 to Sept 1954. Organization is based on materials, those covered including germanium, silicon, carbon, boron, selenium and selenides, tellurium and tellurides, intermetallics, oxides, sulfides and halides. Included also are abstracts on fluorescence and phosphorescence.

1955 Book of ASTM Standards: Part 1—Ferrous Metals. *American Society for Testing Materials, Philadelphia, Pa. Cloth 6 by 9 in. 1834 pp. Price $13.50.*

This is the first part of the triannual revision of the Book of Standards to be released. Part 1 contains 315 standards, 125 of which are new or have been revised since publication of the 1954 supplement. In all, 211 are new or revised since publication of the 1952 edition.

Part 1 covers the standard and tentative specifications, methods of test and definitions for various steel mill products, corrosion resisting steel, metallic coatings for steels, welding rods, wrought iron, cast iron, malleable iron, ferro alloys, magnetic materials and metal powders. General methods of testing are included also.

American Welding Society Recommended Practices: Part 1D, Metallizing Flat Surfaces. *Paper. 10 pp. Price $0.50.* Recommended Practices for Interruption of Heat

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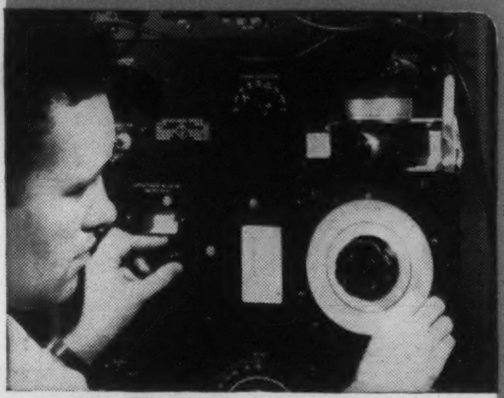
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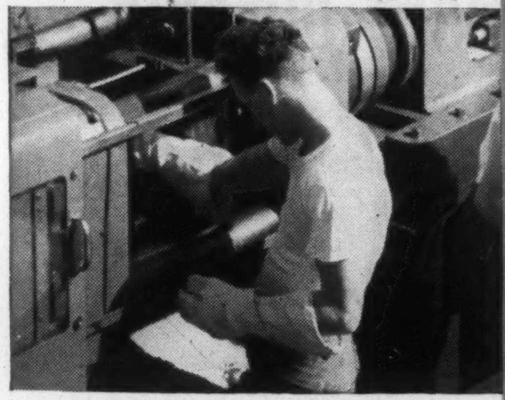
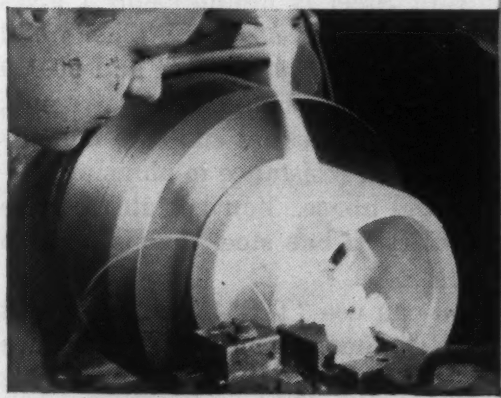
Physical Testing Laboratory


Injection Molding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BOOKS

Treatment Cycles for Low Chromium-Molybdenum Steel Piping Materials. *Paper. 4 pp. Price $0.50.* The Welding of Austenitic Chromium-Nickel Steel Piping and Tubing. *Paper. 25 pp. Price $1.00. The American Welding Society, Inc., New York 18, N. Y. 1955.*

Metallizing Flat Surfaces provides an authoritative source of information on equipment requirements, surface preparation, spraying and finishing procedures for restoring flat parts to size or providing specific surface characteristics.

Recommended Practices for Interruption of Heat Treatment deals with heat cycles in the welding of piping materials containing up to 5 chromium-1% molybdenum. This publication covers present practices in the power, petroleum, chemical and related fields.

Welding of Austenitic Chromium-Nickel Steel Piping and Tubing discusses the suitability of various stainless steel grades for welding pipe, suitable welding processes, the proper selection of filler metal, pipe welding techniques and inspection methods.

REPORTS

Magnets Investigations of Permanent Magnet Alloys. Final report on Contract no. W 36-039-sc-32117. *H. F. Graff, Arnold Engineering Co., Chicago, Ill. May 1948. 51 pp. diagrams, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C. $1.50.*

PB 111664

A study of the magnetic properties of 140 alloy compositions varying in composition from Alnico V as a standard.

Coatings for aluminum PRELIMINARY TESTS OF ALUMINUM SPECIMENS WITH BIREFRINGENT COATING PERMANENTLY DEFORMED BY IMPACT. *J. Duffy and C. Mylonas. Brown University. Graduate Division of Applied Mathematics,*

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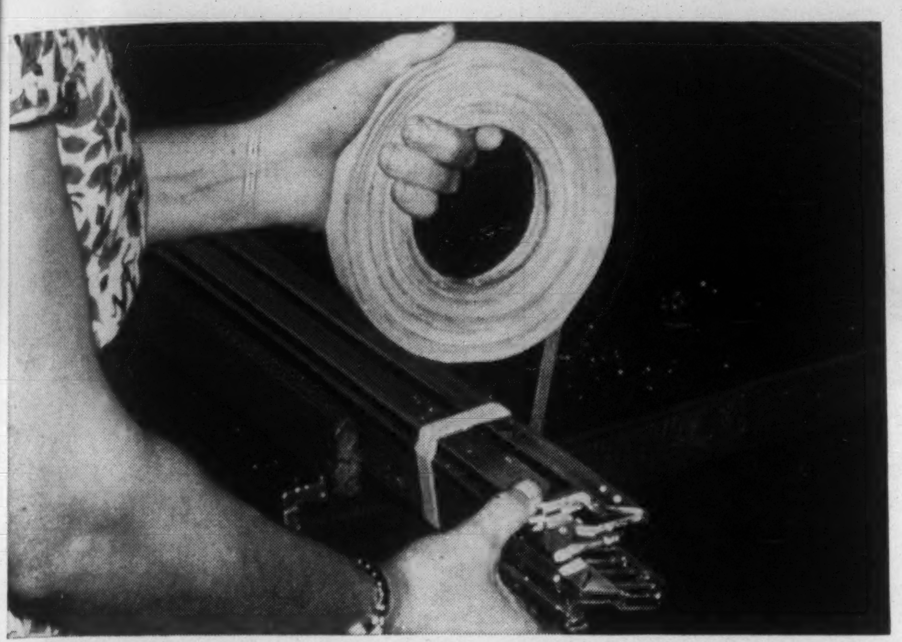

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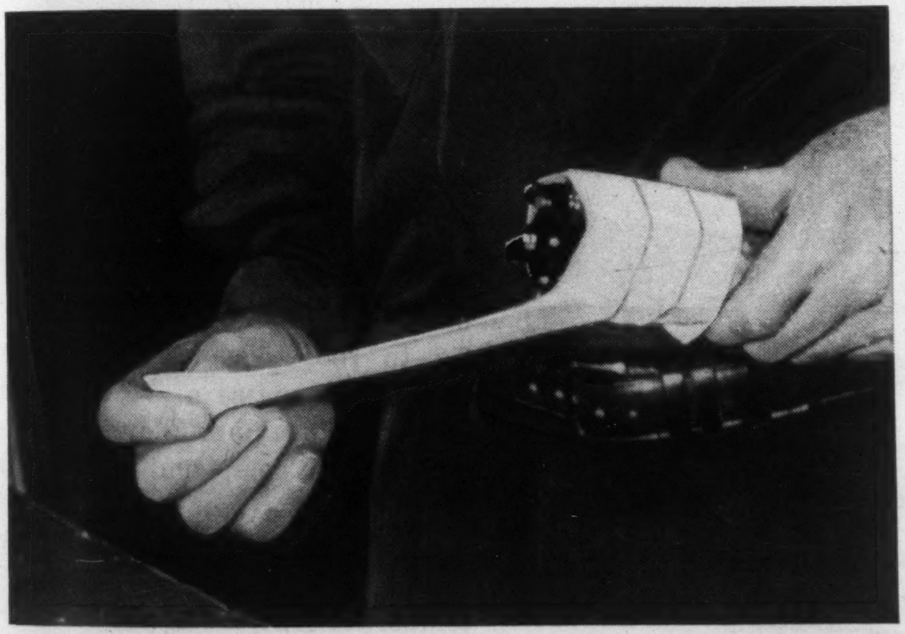

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REPORTS

Providence, R. I. July 1955. 11 pp. photos, table. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $2.40, ph $3.30. PB 118214

The ability of birefringent coatings made of epoxy resins to follow the deformation of metals under impact loads was tested with coated aluminum beams subjected to the moderate impact of the Charpy hammer, and with aluminum plates subjected to the severe impact of .38 and .45 caliber pistol bullets. In all but one case of very severe impact indentation the coatings followed the deformations without cracking or breaking off, and were used as indicators of the permanent strains of the metal specimens.

Heating aluminum TENSILE PROPERTIES OF 7075-T6 AND 2024-T3 ALUMINUM ALLOY SHEET HEATED AT UNIFORM TEMPERATURE RATES UNDER CONSTANT LOAD. *George J. Heimerl and John E. Inge. U. S. National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Washington 25, D. C.* PB 118021

Results are presented of test to determine the effect of heating at uniform temperature rates from 0.2 to 100 F per second on the tensile properties of 7075-T6 and 2024-T3 aluminum alloy sheet under constant-load conditions. Yield and rupture stresses, obtained under rapid-heating conditions, are compared with results of elevated-temperature stress-strain tests for ½ hr exposure.

Creep of aluminum joints CREEP AND CREEP-RUPTURE CHARACTERISTICS OF SOME RIVETED AND SPOT-WELDED LAP JOINTS OF AIRCRAFT MATERIALS. *Leonard Mordfin. U. S. National Advisory Committee for Aeronautics. June 1955. 53 pp. photos, diagrams, graphs, tables. Order from National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Washington 25, D. C.* PB 118017

Equipment, test techniques, and results are presented for an exper-

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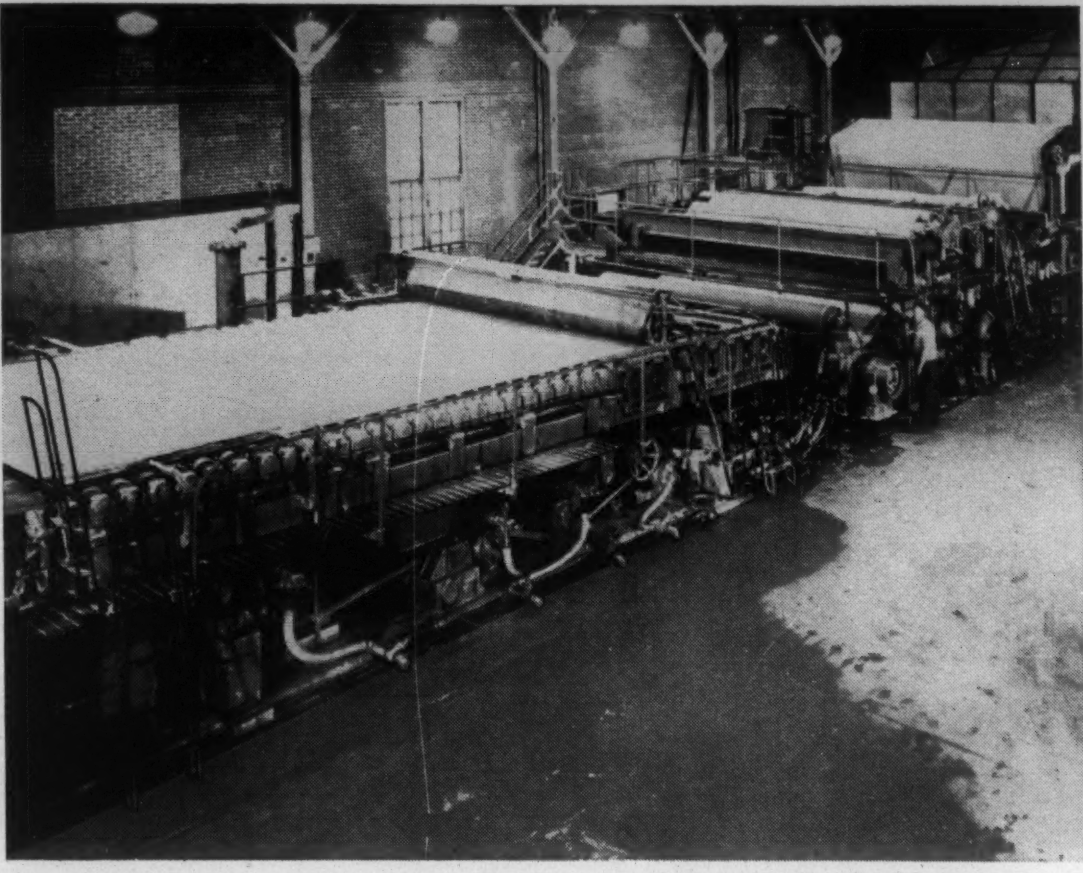

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REPORTS

imental investigation of the creep of lap joints. Riveted aluminum-alloy joints fabricated from 75S-T6 and 24S-T3 sheet with 24S and 24S-T31 rivets were tested at 300, 400, and 500 F. Spot-welded joints of ¼ hard, type 301 stainless steel were tested at 800 F. Each type of joint was also tested in tension at room temperature.

AEC Reports

The following atomic energy reports may be purchased by ordering from the agency listed with each report. Since no PB numbers are indicated, order by series and number.

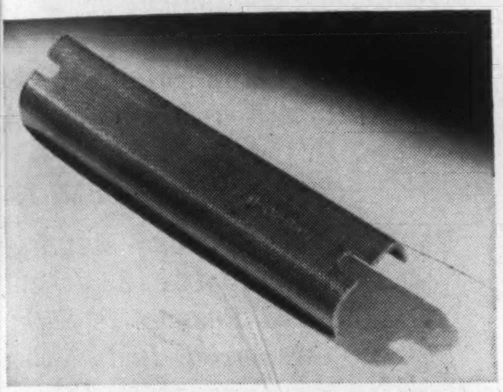
AN INVESTIGATION OF SCALING OF ZIRCONIUM AT ELEVATED TEMPERATURES. Quarterly status report no. 8. *W. M. Baldwin, Jr., H. M. Green and H. E. Tuchschmid. Dept. of Metallurgical Engineering. Case Inst. of Technology. June 1955. Contract No. AT(11-1)-258. 6 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $1.80, ph $1.80* AECU-3032

ANODIZING AS A MEANS OF EVALUATING THE CORROSION RESISTANCE OF ZIRCONIUM ALLOYS. *R. D. Misch. Argonne National Laboratory. Dec. 1953. Contract W-31-109-ENG-38. 88 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $4.80, ph $13.80* ANL-5229

ATTACK ON METALS BY BISMUTH-LEAD-TIN ALLOY AT ELEVATED TEMPERATURES. *W. D. Wilkinson. Argonne National Laboratory. Jan. 1954. Contract W-31-109-eng-38. 73 pp. Available from Library of Congress, Photoduplication Service, Publication Service, Publications Board Project, Washington, D. C. Mi $4.50, ph $12.30* ANL-5262

ENAMELING OF ZIRCONIUM. *J. Schultz, H. P. Tripp, B. W. King, and W. H. Duckworth. Battelle Memorial Inst., Columbus, Ohio. Apr. 1955. Contract No. W-7405-eng-92. 24 pp. Available from*

C-D-F MACHINES TO CLOSE TOLERANCES. Great accuracy is required to furnish ball bearing race retainers made from fine weave cotton fabric Dilecto rolled laminated plastic tubing. When plastics can do a better job than other materials, come to C-D-F for technical and production help.



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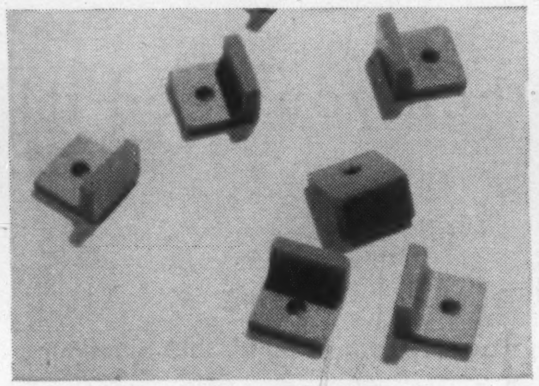

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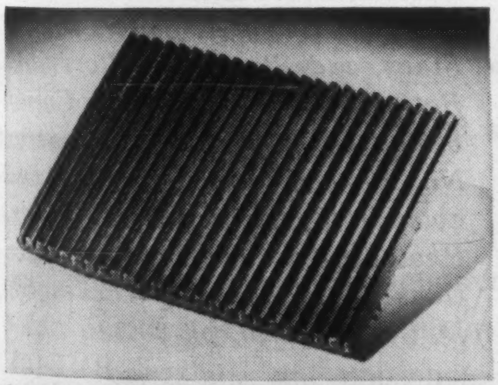

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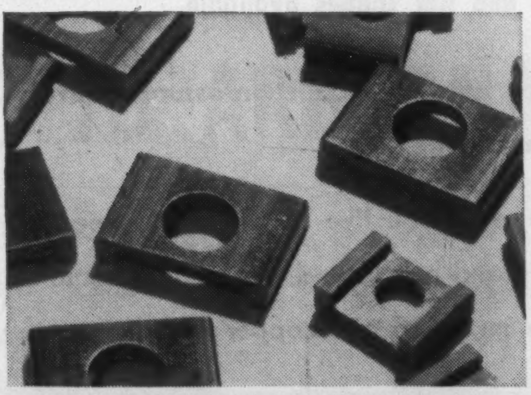

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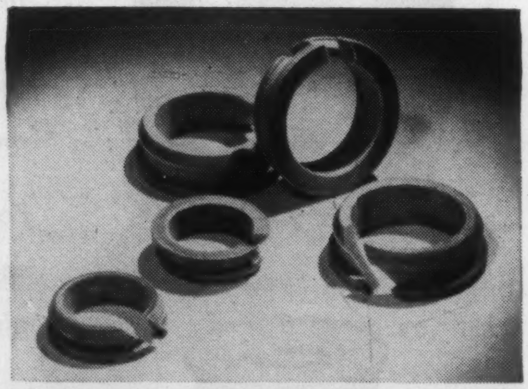

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Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $2.70, ph $4.80 BMI-994

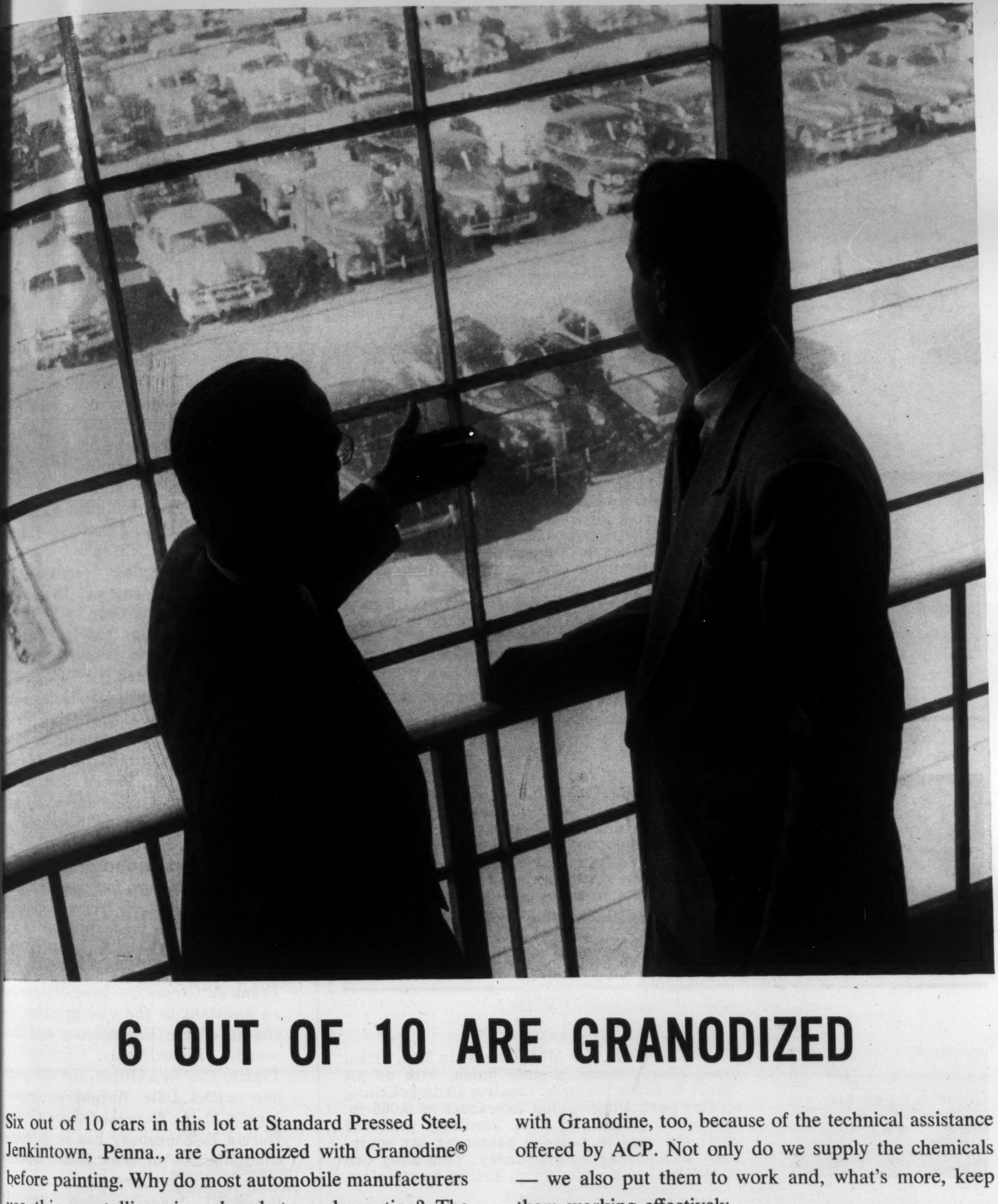
INITIAL INVESTIGATION OF NIOBIUM AND NIOBIUM-BASE ALLOYS. *Henry A. Saller, John T. Stacy, and Stanley W. Porembka. Battelle Memorial Inst., Columbus, Ohio. May 1955. Contract No. W-7405-eng-92. 40 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C.* BMI-1003

ELECTROPLATED METALS ON NIOBIUM. *John G. Beach and C. L. Faust. Battelle Memorial Inst., Columbus, Ohio. May 1955. Contract No. W-7405-eng-92. 8 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $1.80, ph $1.80.* BMI-1004

EMBRITTLEMENT OF MULTIPASS WELDS IN ZIRCALOY 2. *John T. Niemann and Raeman P. Sopher. Battelle Memorial Inst., Columbus, Ohio. June 1955. Contract No. NObs-65057. 19 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $2.40, ph $3.30* BMI-1006

INVESTIGATION OF WROUGHT IRON-CHROMIUM-ALUMINUM ALLOYS CONTAINING PLATINUM AND PALLADIUM. *Henry A. Saller, John T. Stacy, and Stanley W. Porembka. Battelle Memorial Inst., Columbus, Ohio. July 1955. Contract No. W-7405-eng-92. 20pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $2.40, ph $3.30* BMI-1017

ULTRASONIC WELDING OF ALUMINUM. *J. Byron Jones, Carmine F. DePrisco, and John G. Thomas. E. I. du Pont de Nemours & Co. Feb. 1955. Contract AT-(07-2)-1. 48 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Mi $3.30, ph $7.80* DP-107



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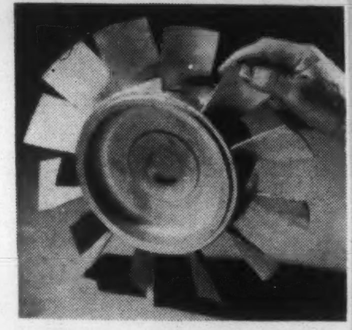
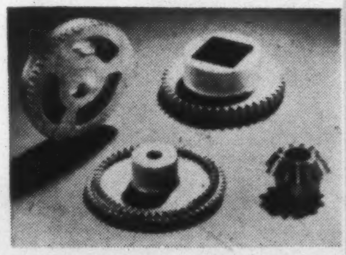
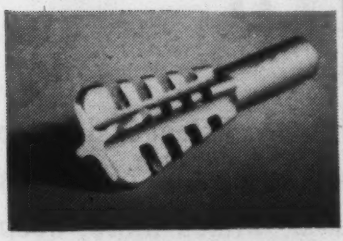


HIGH STRENGTH, LIGHT WEIGHT AND DIMENSIONAL ACCURACY are required in this 6000 rpm air impeller—which drives a generator in aircraft tow target. Universal makes them of aluminum alloy 356 T6 poured at low temperature under vacuum in cast iron permanent mold with plaster core. Blade thickness decreases from 3/32 in. maximum to 0.015 in. at trailing edge—blade detail accuracy is possible only with one-piece plaster core. Impeller meets aeronautical materials and x-ray specifications.



COMPLEX GEARS with 90,000 psi minimum tensile strengths are plaster mold cast by Universal in aluminum, bronze and manganese bronze. Patented low temperature pouring process, developed for highly stressed castings, gives much denser structure and unusually high strengths in nonferrous alloys. Accurate detail and 1/32 in. sections are produced consistently.



DAIRY AND FOOD MIXER cast in 22% nickel brass alloy. Smooth surface finish, with no pit marks to catch bacteria, requires little polishing on this part. Dimensional tolerances of 0.005 in. are held in teeth and slots. Similarly produced parts are used in railroad passenger car equipment and packaging machinery. This alloy can be polished to a white finish similar to stainless.

UNIVERSAL CASTINGS CORP.

For additional facts send for Universal's new catalog "The Key to Product Improvement." Use coupon at top.

5821 WEST 66th STREET
CHICAGO 38, ILLINOIS

For more information, turn to Reader Service Card, Circle No. 500

NEWS OF ENGINEERS COMPANIES SOCIETIES

NEWS OF ENGINEERS

Richard B. Hubbard has been appointed president, ERCO Div., ACF Industries, Inc.

Dr. Rush A. Lincoln has been made technical director, Allegheny Ludlum Steel Corp. **Dr. Gunther Mohling** has replaced Dr. Lincoln as the firm's chief metallurgist; **W. W. Dyrkacz** has moved to Dr. Mohling's former position of manager of quality control, Watervliet Plant; and **Dr. E. E. Reynolds** was named associate director of research to fill the vacancy left by Mr. Dyrkacz.

Kay Miller has been named assistant chief engineer, American Tractor Corp.

Joseph A. Cerny has been appointed director of engineering, Bryant Industrial Products Corp.

Dr. W. N. Stoops has been named associate director, Research Department, Carbide and Carbon Chemicals Co. Other changes in the company's Research Department include the appointment of **Dr. H. C. Chitwood, B. J. Cottrell, Dr. Benjamin Phillips, G. M. Powell** and **A. T. Walter** as assistant directors, and **Dr. D. M. Young** as assistant to the director.

Leslie E. Simon, formerly assistant chief of ordnance for research and development, U. S. Army Ordnance Corps, has been made director of the Research and Development Div., The Carborundum Co.

Frank A. Grooss has been designated an assistant to the vice president in charge of the Engineering and Research Departments, Caterpillar Tractor Co. In addition, the company has named **Dale Wright** as metallurgist in the General Offices Group.

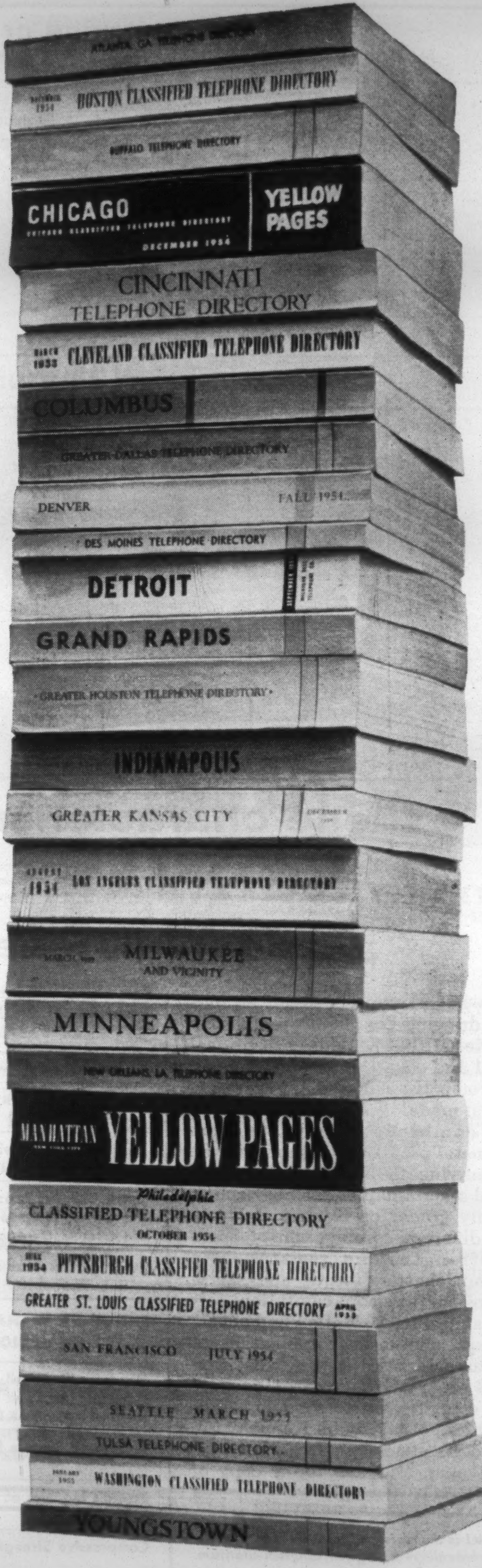
Harold E. Kingsbury has been made chief engineer of West Coast Operations, Chrysler Corp.

Bernard L. Jones has been given the newly-created position of chief engineer, Crucible Steel Co. of America. At the same time, **Tore Wallin** was named assistant chief engineer for the company.

Ralph W. Rawson has joined Fansteel Metallurgical Corp. as chief engineer to take charge of the company's newly-established Centralized Engineering Department.

George P. Holman has been appointed senior process development

Here's where you get the answers to steel problems


ATLANTA, GA. TELEPHONE DIRECTORY
BOSTON CLASSIFIED TELEPHONE DIRECTORY
1954
BUFFALO TELEPHONE DIRECTORY
CHICAGO
DECEMBER 1954
YELLOW PAGES
CINCINNATI TELEPHONE DIRECTORY
CLEVELAND CLASSIFIED TELEPHONE DIRECTORY
MARCH 1955
COLUMBUS
GREATER DALLAS TELEPHONE DIRECTORY
DENVER
FALL 1954
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MANHATTAN YELLOW PAGES
Philadelphia
CLASSIFIED TELEPHONE DIRECTORY
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PITTSBURGH CLASSIFIED TELEPHONE DIRECTORY
1954
GREATER ST. LOUIS CLASSIFIED TELEPHONE DIRECTORY
SAN FRANCISCO
JULY 1954
SEATTLE MARCH 1955
TULSA TELEPHONE DIRECTORY
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1955
YOUNGSTOWN

●Look under "The Youngstown Sheet and Tube Company" in one of these alphabetical or classified phone books.

They represent the 28 conveniently located district sales offices Youngstown maintains across the country. Offices staffed by men who know the steel business. Men who know and understand **your** steel problems. Men who are qualified to help you get the specific steel you need.

When you want answers to steel problems in a hurry, just call the Youngstown office nearest to you.

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THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

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SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - WIRE - HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - BLACK PLATE - RAILROAD TRACK SPIKES - MINE ROOF BOLTS

For more information, turn to Reader Service Card, Circle No. 351

CHEMICAL COMPOSITION OF HARD CARBIDE INGREDIENTS OF KENNAMETAL

	Tungsten Carbide (WC)	Titanium Carbide (TiC)	Tungsten-Titanium Carbide ($WTiC_2$)	Tantalum Carbide (TaC) with less than 5% CbC
Tungsten (W)	92.50% (min)		67.00-71.00%	
Titanium (Ti)		79.80-80.20%	18.00-21.00%	
Tantalum (Ta)				93.45-93.65%*
Carbon (C)	6.05-6.15%	19.20-19.60%	9.20-9.40%	6.35-6.55%
Columbium (Cb)				5.00% (max)

*Including CbC

MAXIMUM IMPURITY CONTENT

	WC	TiC	$WTiC_2$	TaC
Free Carbon	0.05%	0.20%	0.05%	......
Fe	0.15%	0.40%	0.10%	0.10%
Mo	0.10%	......	0.30%	......
Ni	......	......	0.20%	......
Cb+Ta	0.50%	......	0.50%	......
Ti	0.20%	......	......	0.50%
Si	0.10%	0.10%	0.10%	......
Mn	0.10%	0.10%	0.10%	......
V	......	0.10%	......	......
Zr	......	......	......	0.20%
Sn	......	......	......	0.10%
W	......	0.20%	......	0.30%
Cr	......	0.10%	......	......
N_2	......	0.30%	......	......

These characteristics make KENNAMETAL* a unique material

Often, what is required to get an idea off the drawing board into production is a material that provides exceptional physical and chemical properties. Such a material is Kennametal . . . the hardest metal made.

The combined properties that Kennametal provides . . . shown in the accompanying tables . . . make this material stand uniquely alone. Each of the many grades of Kennametal provide a different combination of hardness, strength, and resistance to deflection, chatter, torque and vibration, erosion, abrasion, cavitation, corrosion, annealing, oxidation and shock.

Perhaps one or a combination of these characteristics is just what you need to get YOUR idea into production. We invite you to send for additional information about Kennametal. Write to KENNAMETAL INC., Latrobe, Pennsylvania, and ask for a copy of Booklet B-111.

7293

RANGE OF PHYSICAL PROPERTIES OF VARIOUS GRADES	
Specific Gravity gms/cc	11.90-15.15
Thermal Conductivity (cal/°C/cm/sec)	.068-.207
Electrical Conductivity (% of Copper Standard)	4.3-10.0
Coeff. Thermal Expansion ($\times 10^{-6}$/°F up to 1200°F)	2.5-4.0
Coeff. Thermal Expansion ($\times 10^{-6}$/°C up to 650°C)	4.5-7.2
Magnetic Permeability (μ Induction)	1.5-3.0

RANGE OF MECHANICAL PROPERTIES OF VARIOUS GRADES	
Hardness (Rockwell A)	85-93
Hardness (Rockwell C)	67-82
Hardness (Knoop-K100)	1700-2100*
Transverse Rupture (psi)	175,000-385,000
Young's Modulus of Elasticity (psi)	61,600,000-94,300,000
Compressive Strength (psi)	518,000-800,000
Torsional Strength (Shearing Stress psi)	100,000-186,000
Tensile Strength (psi)	To 150,000

*Partial Range

**Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.*

INDUSTRY AND
KENNAMETAL
...Partners in Progress

For more information, turn to Reader Service Card, Circle No. 409

news of | ENGINEERS

engineer in General Electric Co.'s Manufacturing Services. In addition

Albert Hansen, Jr., previously manager of advanced engineering for the company's Instrument Department, was given the new appointment of manager of engineering for the Rectifier Department.

Dr. Cledo Brunetti has acquired the position of director of engineering research and development, Mechanical Div., General Mills, Inc.

George H. Ripley, formerly manager of the Sunflower Ordnance Works, has been transferred to the Engineering Department of Hercules Powder Co. in Wilmington, Del., as project engineer. **Richard C. Tucker** has been appointed manager of Sunflower to succeed Mr. Ripley.

Edmund M. Wise has been promoted to assistant to the vice-president-manager of the Development and Research Div., The International Nickel Co., Inc.

Gilbert R. Semans has been made assistant director of metallurgy and research, Jessop Steel Co. In addition to his new duties at Jessop, Mr. Semans will continue his teaching activities at the University of Pittsburgh's Graduate School of Metallurgy.

E. B. Suydam has been appointed president of Linde Air Products Co.

Loren C. Hurd has been named president and a director, Metals Disintegrating Co., Inc.

Beverly W. Duncan has been made head of research and development, Misco Precision Casting Co.

Keith Conrad has been advanced to chief engineer, Pacific Coast Div., Owens-Illinois Glass Co. **Robert R. Denman** succeeds Mr. Conrad as chief project engineer of the General Research Department.

Clarence Wantz has been selected chief engineer in charge of the Engineering Department, Robertshaw Thermostat Div., Robertshaw-Fulton Controls Co.

Donald V. Sarbach has assumed the newly-created position of research director, Hewitt-Robins Inc.

Virgil W. McDaniel has been named division president of Interchemical Corp.'s Cotan Div.

Dr. Ronald C. Vickery has become associated with the chemistry and metallurgy research staff, Horizons Inc.

(News of Companies on p. 216)

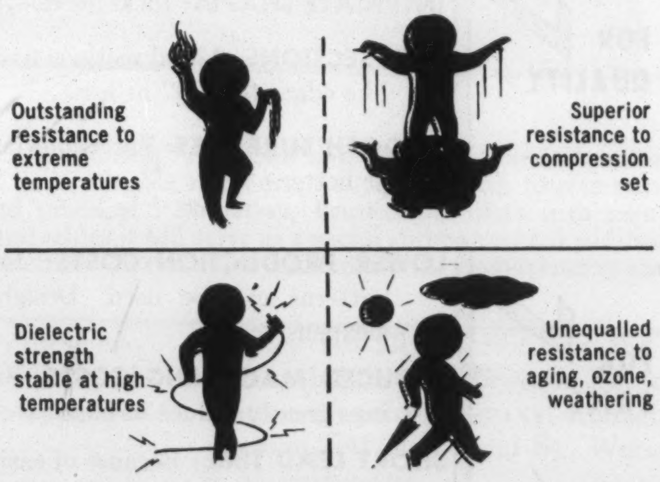
COLD RESISTANCE?
silicone rubber stays flexible at minus 150° F

Looking for *really* cold-resistant rubber? General Electric's Class 500 silicone rubber offers flexibility down to 150 F below zero! Unmatched in low-temperature serviceability by any known elastomer, it has become standard in the aircraft industry for seals and gaskets around airframe openings. With essentially the *same flexibility* at minus 90 F as at room temperature, it greatly simplifies your design problems.

Where can YOU use G-E silicone rubber?

There's a kind for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 300 offers the best recovery after compression *of any known rubber!* Class 700 provides serviceability *up to 600 F!* Which class is best for *you?*

G-E silicone rubber provides...


Outstanding resistance to extreme temperatures
Superior resistance to compression set
Dielectric strength stable at high temperatures
Unequalled resistance to aging, ozone, weathering

● ●

FREE!
send today for a
NEW, REVISED
"LIGHTNING SELECTOR"!

Progress Is Our Most Important Product

GENERAL ELECTRIC

SILICONE PRODUCTS DEPARTMENT
GENERAL ELECTRIC COMPANY
Section 61-2E
Waterford, New York

Please send me, at no obligation, technical data on G-E silicone rubber, including a newly revised "Lightning Selector" and up-to-date list of fabricators

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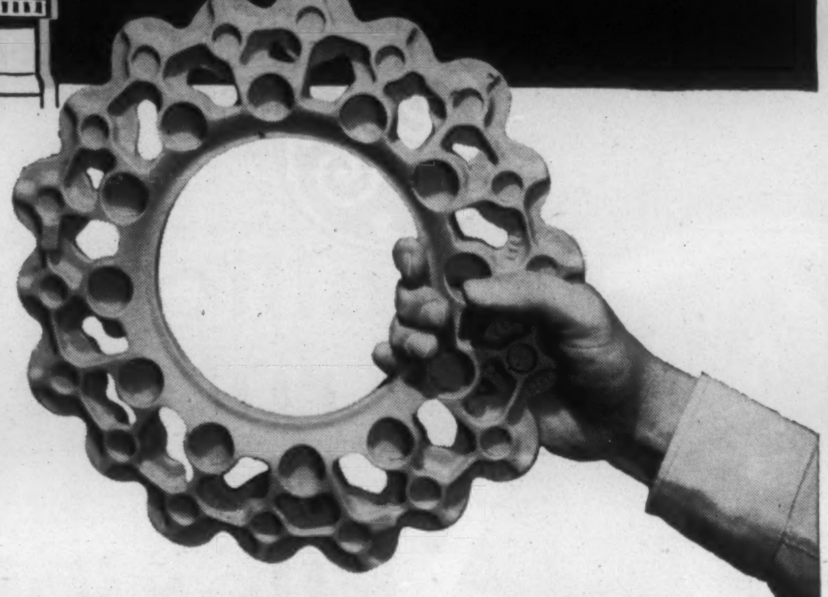
Firm________________________

Street________________________

City____________ Zone____ State________

IN CANADA: MAIL TO CANADIAN GENERAL ELECTRIC COMPANY, LTD., TORONTO

For more information, turn to Reader Service Card, Circle No. 354



CERAMICAST*

Typical of the intricate design and thin metal sections possible with the CERAMICAST process is this backing plate for a jet aircraft brake.

Lebanon's new casting process for...

CLOSE TOLERANCE STEEL CASTINGS AT LOW COST

FOR QUALITY

TOLERANCES as close as ±.003" to .005" per inch.

INTRICATE SHAPES: Ideal for castings of complex design.

THIN SECTIONS: Metal sections to 3/32 of an inch. Knife-like edges to .030" or less.

SMOOTH SURFACES: Variations held to 125 micro-inches or better.

FOR PRICE

LOWER PRODUCTION COSTS: Jobbing wood or metal patterns can be used. Design changes quick and inexpensive.

REDUCED MACHINING COSTS: Smooth, accurate castings greatly reduce or eliminate machining.

SHORT LEAD TIME: Because of easily constructed pattern equipment and relatively simple production process.

ADAPTABLE TO MANY CASTING SIZES AND ALLOYS—casting weights up to one hundred pounds or more. Carbon steel, conventional low alloys, stainless steels and the superalloys.

SEND US YOUR BLUEPRINTS. Our sales engineering department will show you how the revolutionary Lebanon CERAMICAST Process can be adapted to your project design.

*produced under licensing agreement with Shaw Processes, Ltd., London, England.

CIRCLE L ®

LEBANON STEEL FOUNDRY
113 LEHMAN STREET LEBANON, PENNSYLVANIA

CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS

For more information, turn to Reader Service Card, Circle No. 367

news of | COMPANIE

Allied Research Products, Inc., ha completed a plant expansion tha doubles the area available for research and development facilities The new quarters consist of an addition to the structure located at 4004 E. Monument St., Baltimore, Md.

American Cyanamid Co. and **The Formica Co.** have announced that negotiations are in progress whereby Cyanamid will acquire the business and assets of The Formica Co. Also revealed were plans already developed by Formica for a two and one-half million dollar expansion program at the Evendale, Ohio, plant calling for a 20% increase in sheet laminating facilities.

The Borden Co. has acquired the capital stock of **American Resinous Chemicals Corp.** and **Reslac Chemicals, Inc.,** to further diversify its activity in thermoplastics.

Balfor Industries, Inc., a newly-organized company with offices and plant at 1815 Webster Ave., New York 57, N. Y., has announced that it is now in full production in all phases of Teflon processing.

The **Dalic Metachemical Ltd.** of Toronto, Canada, has appointed **Marlane Development Co., Inc.,** as U. S. distributor for the Dalic Process of selective localized electroplating.

Ferro Corp. has announced a new $240,000 building and equipment expansion program for its Color Division.

Hunter Douglas Corp. has changed its name to Hunter Douglas Aluminum Corp.

Kelsey-Hayes Wheel Co. has completed construction of a 100,000 sq ft addition to its aircraft parts plant in Jackson, Mich.

Mallory-Sharon Titanium Corp. has completed purchase of the Niles **Rolling Mill, Niles, Ohio,** as the first step in an expansion program designed to double capacity for production of titanium and titanium alloys during 1956.

Mayon Plastics has occupied its new and larger building at Hopkins, Minn.

Midland Industrial Finishes Co. has broken ground for a new addition to its plant in Waukegan, Ill.

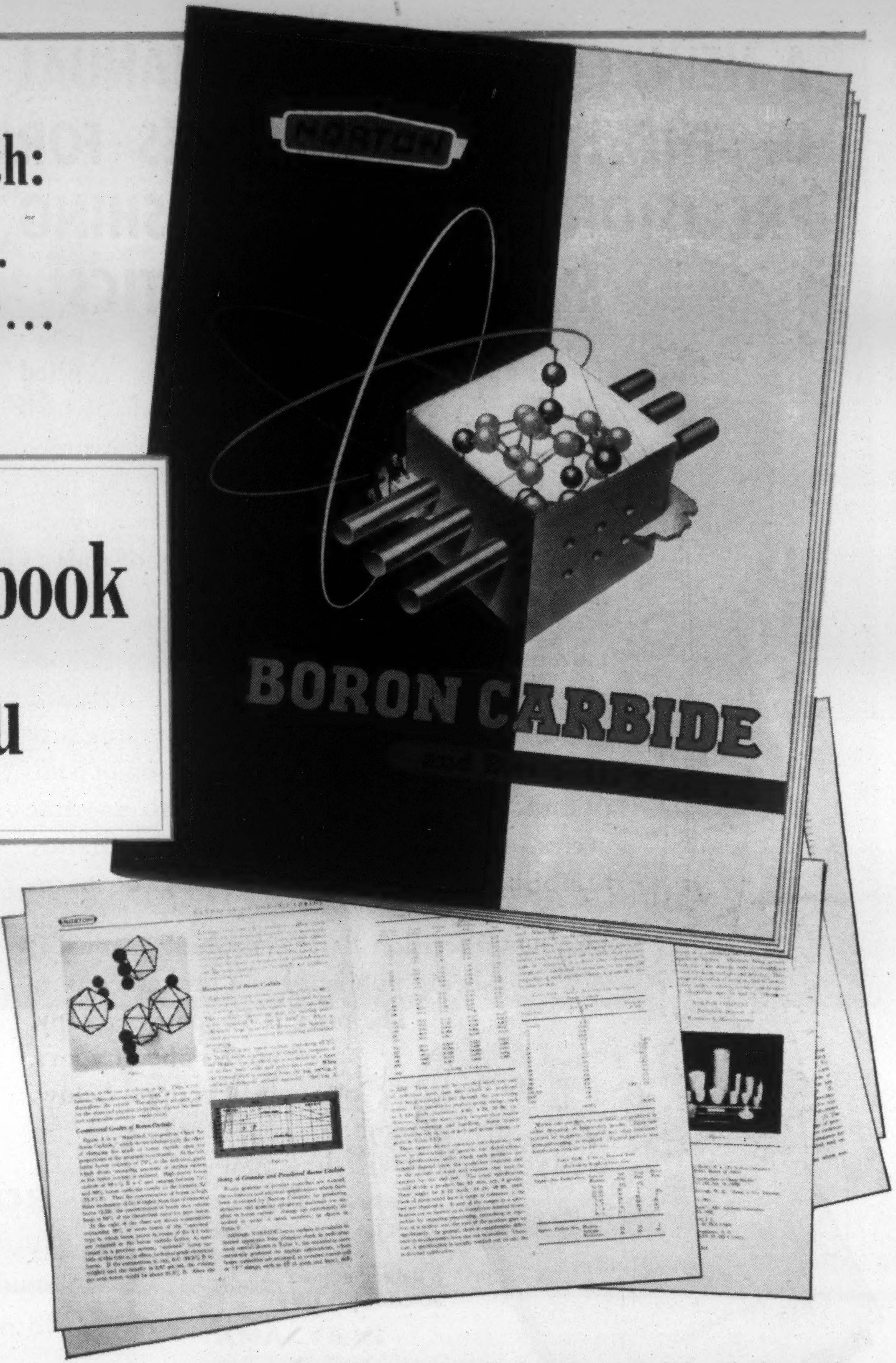
Misco Precision Casting Co. recently announced that it is building a new plant in Muskegon, Mich., for the production of investment castings.

National Starch Products Inc. has opened a new plant in Plainfield, N. J., which provides additional fa-

f you are concerned with:

Reactor development...
Atomic energy projects...
Nuclear problems...

This new data book will help you



This new free Norton *"Handbook on Boron Carbide and Elemental Boron"*, is a valuable reference, containing both fundamental data and practical information. Printed in colors with many charts and tables it will serve as a useful and permanent addition to the reference files of those concerned with atomic energy and related fields.

In nuclear science and engineering the importance of the neutron absorption reaction of the boron isotope B^{10} is well recognized.

Now, for the first time, available data on the development of numerous stable, boron-rich materials have been compiled and coordinated by Norton in one convenient reference book.

This book is the *"Handbook on Boron Carbide and Elemental Boron"* — a compact source of technical information on materials made by Norton for use in the atomic energy field.

A partial list of the table of contents includes: *Boron for neutron absorption . . . Technical grade boron . . . Properties of boron . . . Commercial grades of boron carbide . . . Radiation damage to boron carbide . . . Bonded boron carbide (carbon, silicate, plastic, metal) . . . Boron nitride . . . Metal borides.* These and many other subjects are fully described and illustrated with tables, charts and photographs.

A Quarter-Century of Experience

Work in Norton laboratories on boron compounds began some 25 years ago. This included the development of NORBIDE* boron carbide, the hardest material yet produced commercially. Norton facilities for producing NORBIDE wear-resistant articles and abrasive have been expanded to supply boron carbide in numerous forms for atomic energy applications.

Recent Norton development has been aimed at improving the quality, increasing the production and reducing the costs of various boron-rich products. As a result, Norton now produces these materials to highest purity standards, at prices ranging between one-half and one-tenth of former pricing.

Other Norton Electric Furnace Products

of special interest to nuclear engineers include ALUNDUM* fused alumina, CRYSTOLON* silicon carbide, MAGNORITE* magnesium oxide, FUSED ZIRCONIA and various refractory carbides, oxides and nitrides.

Besides being the basic ingredients of the famous Norton Refractory ℞'s — refractories *engineered and prescribed* for the widest range of conventional applications — these high-melting materials are finding many new and valuable uses in atomic energy projects.

They are all described in the new Norton handbook. For your free copy, write to NORTON COMPANY, Refractories Division, 341 New Bond St., Worcester 6, Massachusetts.

NORTON
REFRACTORIES
Engineered... ℞... Prescribed

Making better products... to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries.

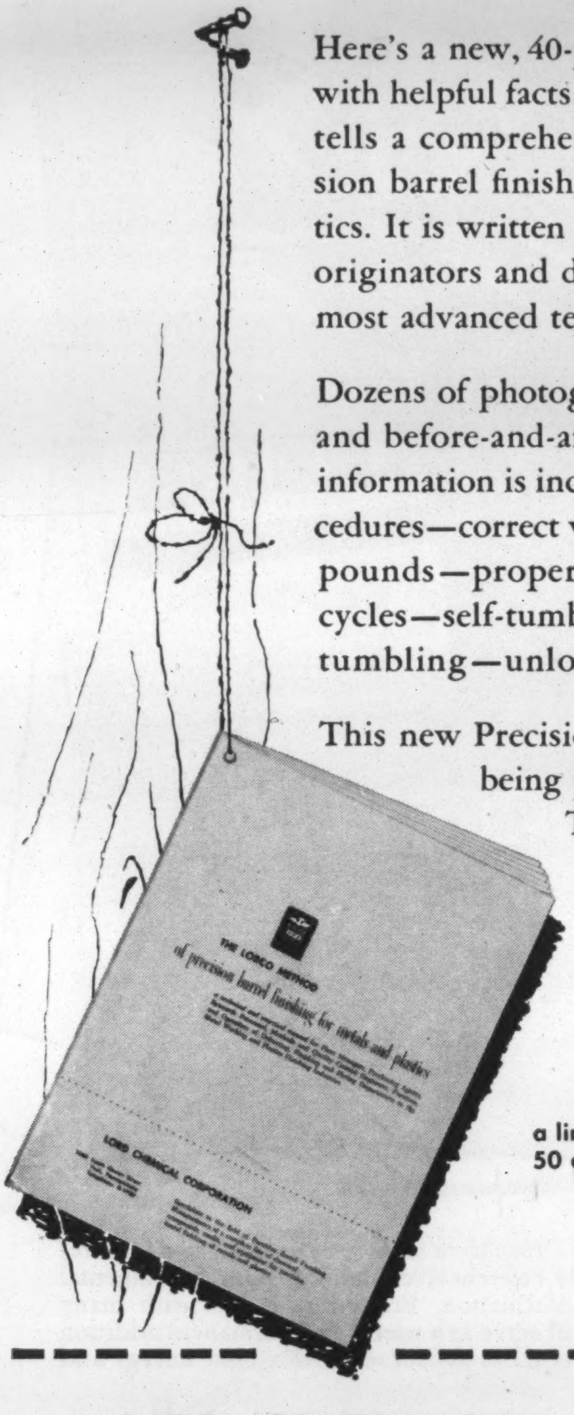
For more information, turn to Reader Service Card, Circle No. 320

A NEW, COMPREHENSIVE MANUAL OF THE LATEST TECHNIQUES FOR PRECISION BARREL FINISHING METALS and PLASTICS

Here's a new, 40-page, practical guide . . . filled with helpful facts and processing data . . . which tells a comprehensive story of modern precision barrel finishing for both metals and plastics. It is written in step-by-step fashion by the originators and developers of many of today's most advanced techniques.

Dozens of photographs show actual operations and before-and-after parts. A fund of valuable information is included on: proper loading procedures—correct water levels—selection of compounds—proper media types and sizes—time cycles—self-tumbling—free tumbling—fixture tumbling—unloading and drying of parts.

This new Precision Barrel Finishing manual is being published as a limited edition. The price is 50 cents per copy. To obtain yours, please mail coupon below.


THE LORCO METHOD
of precision barrel finishing for metals and plastics
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For more information, turn to Reader Service Card, Circle No. 474

news of | COMPANIES

cilities for the production of rubber and other solvent adhesives.

Northrop Aircraft, Inc., has announced plans for a facilities consolidation program which will include construction of a scientific engineering research center on its Hawthorne, Calif., site.

Reynolds Metals Co. has begun construction of a $5,500,000 aluminum extrusion plant near Richmond, Va.

Snyder Chemical Corp. has changed its name to Synco Resins, Inc.

Union Carbide and Carbon Corp. has formed a Silicones Division to take over the responsibility for the development, manufacture and sale of silicone products. The new division will assume responsibilities in the field of silicones previously handled by **Linde Air Products Co.**

United Pipe Column & Railing Co. has been acquired by **Solar Steel Corp.** The former company will continue operations as a division of Solar.

news of | SOCIETIES

The **American Standards Assn.** has elected H. Thomas Hallowell, Jr., who is president of Standard Pressed Steel Co., as president, and Van H. Leichliter, vice president of operations, American Steel and Wire Div., United States Steel Corp., as vice president.

Mr. Leichliter, in addition, has been honored with an award by the Association for "leadership in advancing the development and use of voluntary standards as instruments of free enterprise."

The **American Welding Society** has appointed Arthur L. Phillips editor of the Welding Handbook.

The **American Zinc Institute** has announced the retirement of Ernest V. Gent as executive vice president and the appointment of John L. Kimberley, formerly secretary of the Institute, as executive vice president in his stead. Mr. Gent will continue to serve the Institute as a special consultant.

The Institute has also announced the appointment of David W. Pettigrew as administrative assistant.

The **American Rocket Society** has elected Harry F. Guggenheim, a leader in the development of aviation since World War I, and in rocket and

HIGH PURITY

TITANIUM CARBIDE

in commercial quantities

TITANIUM CARBIDE is an extremely hard substance with good oxidation resistance at high temperatures. This combination of properties makes its use advantageous in several applications. Among these are **1.** as a component in sintered steel cutting tools, **2.** for jet engine parts and **3.** as a high temperature refractory material.

PROPERTIES

Structure . . . cubic	Hardness . . . . 9 Moh scale
Mp . . . . 5680°F	Mesh Size . . . . 95 to 98%-325

(also finer particle sizes 10 microns max. and 5 microns max.)

ANALYSIS of current commercial production of TAM* Titanium Carbide shows this high purity:

Combined Carbon . . 19.0% Min.	Ti . . 79.0% Min.
Free Carbon . . . . 0.3% Max.	Fe . . 0.2% Max.

AS A DEVELOPER of metals, alloys, chemicals and compounds of both Titanium and Zirconium . . . TAM* is experienced and equipped to serve your needs for these products.

*TAM is a registered trademark.

FOR COMPLETE INFORMATION **TAM** WRITE OUR NYC OFFICE

Registered U. S. Pat. Off.

TITANIUM ALLOY MFG. DIVISION

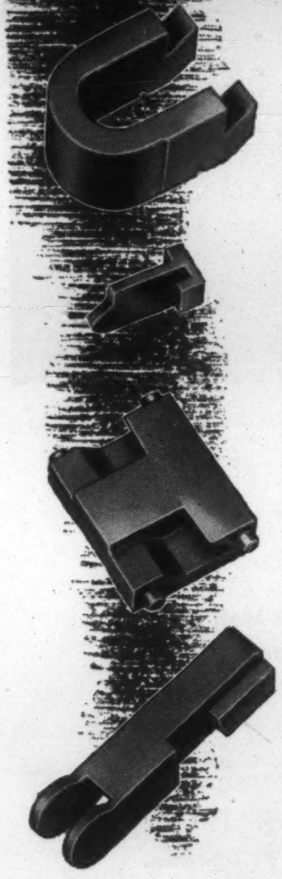
NATIONAL LEAD COMPANY

Executive and Sales Offices: 111 Broadway, New York City
General Offices, Works and Research Laboratories: Niagara Falls, New York

For more information, turn to Reader Service Card, Circle No. 513

Mossberg had 5 REASONS for using . . .

4 HITCHINER INVESTMENT CASTINGS in this new shotgun*. . .



1. PRICE: These four intricately shaped parts could not be machined within cost budgets. HITCHINER Investment Castings were well within the budget allowed.

2. STRENGTH: If machined, choice of metals was limited to those easily worked. HITCHINER Investment Castings requiring little or no machining, offered a wide variety of alloys permitting greater strength at no additional cost.

3. TIME: Production speed was essential in introducing the new gun. HITCHINER, by using comparatively inexpensive one-cavity dies for the original run, helped get the gun on the market on schedule. Later, multiple-cavity dies were used.

4. DESIGN: The four key parts as designed posed difficult manufacturing problems. The HITCHINER Investment Casting process permitted wide latitude in contour and form.

5. APPEARANCE: Obviously components must maintain the appearance of quality in any quality product. HITCHINER produced accurate parts attractive in appearance without extra work or cost.

These are reasons why so many use HITCHINER Investment Castings to solve small parts problems in both small and large production runs . . . send us your drawings and all pertinent data.

A 12 page booklet covering cost, design, application and manufacture of HITCHINER Investment Castings is yours for the asking . . . send for it TODAY.

*The gun is one of the new No. 200 series Pump Action Shotguns manufactured by O. F. Mossberg and Sons, Inc., 998 St. John's St., New Haven 5, Connecticut.

HITCHINER
Manufacturing Company
MILFORD 3, NEW HAMPSHIRE
REPRESENTATIVES IN PRINCIPAL CITIES

For more information, turn to Reader Service Card, Circle No. 378

news of | SOCIETIES

jet propulsion since 1929, to Honorary Membership in the Society.

The Electrochemical Society, as a tribute to the pioneering achievements of Dr. Frederick M. Becket in the field of metallurgy, has established the F. M. Becket Memorial Award. The award is in the form of an annual scholarship aimed at interesting college students in the field of high temperature electric furnace operations. The fund for the award was presented to the Society by Electro Metallurgical Co., and the scholarship to be awarded each year will be approximately $500.

The **Institute of the Aeronautical Sciences** has elected Dr. Edward R. Sharp, director of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, as president for 1956. The Institute also elected the following as vice presidents: William B. Bergen, executive vice president, The Glenn L. Martin Co.; Victor E. Carbonara, president, Kollsman Instrument Corp.; Edgar Schmued, vice president in charge of engineering, Northrop Aircraft, Inc.; and Raymond C. Sebold, vice president for engineering, Convair Div. of General Dynamics Corp.

In addition, the Institute has named Dr. William R. Sears, director of the Graduate School of Aeronautical Engineering at Cornell University, as editor of the *Journal of the Aeronautical Sciences.*

The **Investment Casting Institute** has announced the election of the following five new members: Dean Precision Casting Co.; Lawrence Laboratory; Carbide & Carbon Chemical Co.; Montrose Chemical Co.; and Stratos Div., Fairchild Engine & Airplane Co.

The National Assn. of Corrosion Engineers has elected W. F. Fair, Jr., Tar Products Div., Koppers Co., as president, and W. H. Stewart, Sun Pipe Line Co., as vice-president.

At the same time, NACE has selected two educators to receive the 1956 NACE Awards. The Whitney Award will go to Norman Hackerman, professor of chemistry, University of Texas, and the Speller Award to Mars G. Fontana, professor of metallurgical engineering, Ohio State University. Presentation of awards and installation of officers will take place during the coming twelfth annual conference.

(Meetings & Expositions on p. 222)

Here's how you can help make stainless plate stocks go a LONG way...

Whenever demand outdistances supply you have problems. But any problem can be solved when all hands cooperate. If you keep in mind these "rules of the road" you will be able to add extra mileage to the supply . . .

1. **If you have a D.O. rating, give it to your supplier—it helps him get the necessary nickel, and protects your position on his schedule.**
2. **If you are going to cut plate into smaller pieces, give your supplier the option of furnishing small pieces.**
3. **Plan ahead as much as possible, so your supplier has a reasonable chance to meet your delivery requirements.**
4. **If an alternate analysis or a slight variation in gage is acceptable, let your supplier know.**
5. **Buy "cut-to-shape" pieces and reduce your time and costs of handling scrap.**
6. **Clean out your stainless scrap so that it can get back into production.**
7. **Order only what you need in stainless plate—to exact size.**

Put these simple rules to work . . . it will help you, and all of us, stretch the supply to the limit.

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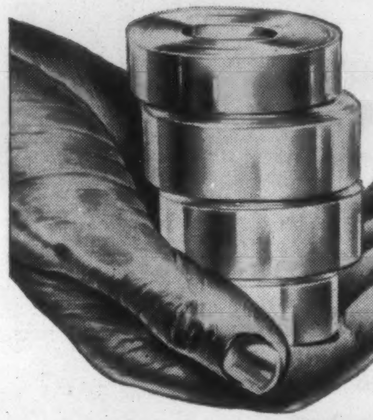
WEIGH FIRST COSTS

of CMP restricted specification cold rolled strip steel



AGAINST CMP ADVANTAGES

True costs of cold rolled strip steel are oftentimes clouded by unfamiliarity of the full potential with a specially tailored product such as CMP processes.

Typical of the reductions in overall manufacturing costs that can often be recorded with the use of CMP restricted specification strip, is the elimination of manual costs involved in the tear-down and re-assembly of components rejected for malfunctioning due to steel dimensional variations. Where precision fitting of components is essential to satisfactory equipment operation, the extra steel cost for close gauge accuracy is more than offset by greater parts production per machine hour and reduction or elimination of rejects at final assembly. Add to this the lower end product cost resulting from longer tool life, fewer coil changes on production equipment and other labor cost items.

The conclusion often is that it pays to buy a premium specification product to lower the cost of an end product employing cold rolled carbon, alloy or stainless strip steel.

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LOW CARBON
HIGH CARBON
Annealed or Tempered
STAINLESS
ALLOY
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Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar 6-8, 1956.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference and exhibition. New York. Mar 12-16, 1956.

PRESSED METAL INSTITUTE, annual spring technical meeting. Cleveland. Mar 14-16, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Aviation Div. Conference. Los Angeles. Mar 14-16, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting. Portland, Ore. Mar 18-21, 1956.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 19-20, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, national production meeting and forum. Cleveland. Mar 19-21, 1956.

AMERICAN SOCIETY OF TOOL ENGINEERS, industrial exposition. Chicago. Mar 19-23, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, production forum and aircraft engineering display. New York. Apr 9-12, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Machine Design Div. Conference. Worcester, Mass. Apr 10-11, 1956.

METAL POWDER ASSN., annual meeting and metal powder show. Cleveland. Apr 10-12, 1956.

MALLEABLE FOUNDERS' SOCIETY, annual market development conference. Chicago. Apr 12-13, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Gas Turbine Power Div. Conference. Washington, D. C. Apr 16-17, 1956.

AMERICAN CERAMIC SOCIETY. New York. Apr 22-26, 1956.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention and exhibition. Atlantic City. May 3-9, 1956.

AMERICAN WELDING SOCIETY, national spring meeting and 4th welding and allied industry exposition. Buffalo, N.Y. May 8-11, 1956.

DESIGN ENGINEERING SHOW, exposition and conference. Philadelphia. May 14-17, 1956.

SOCIETY OF THE PLASTICS INDUSTRY, seventh national plastics exposition. New York. June 11-15, 1956.

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PORTER-CABLE
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CASE HISTORIES FROM
MT. VERNON FILES

No power plane before this Porta-Plane* has ever used such a high speed motor. And when any manufacturer is out to break all precedents, and still sell his product at a low price, he needs every bit of designing and production skill he can find—anywhere.

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This important advantage—low cost—stems directly from the way we are organized here at Mt. Vernon. From die cast to finished casting, Mt. Vernon has both the complete die casting service and the facilities it takes to produce parts like these at minimum cost in any quantity. We have 162,000 square feet of the most modern equipment for making dies and for die casting aluminum and zinc. Mt. Vernon service comprises completely coordinated designing, die-making, casting, and machining, all under one roof.

It will pay you to bring your production specifications to us. We may show you, as we did Porter-Cable, the way to important cost reductions and improved products.

MT. VERNON
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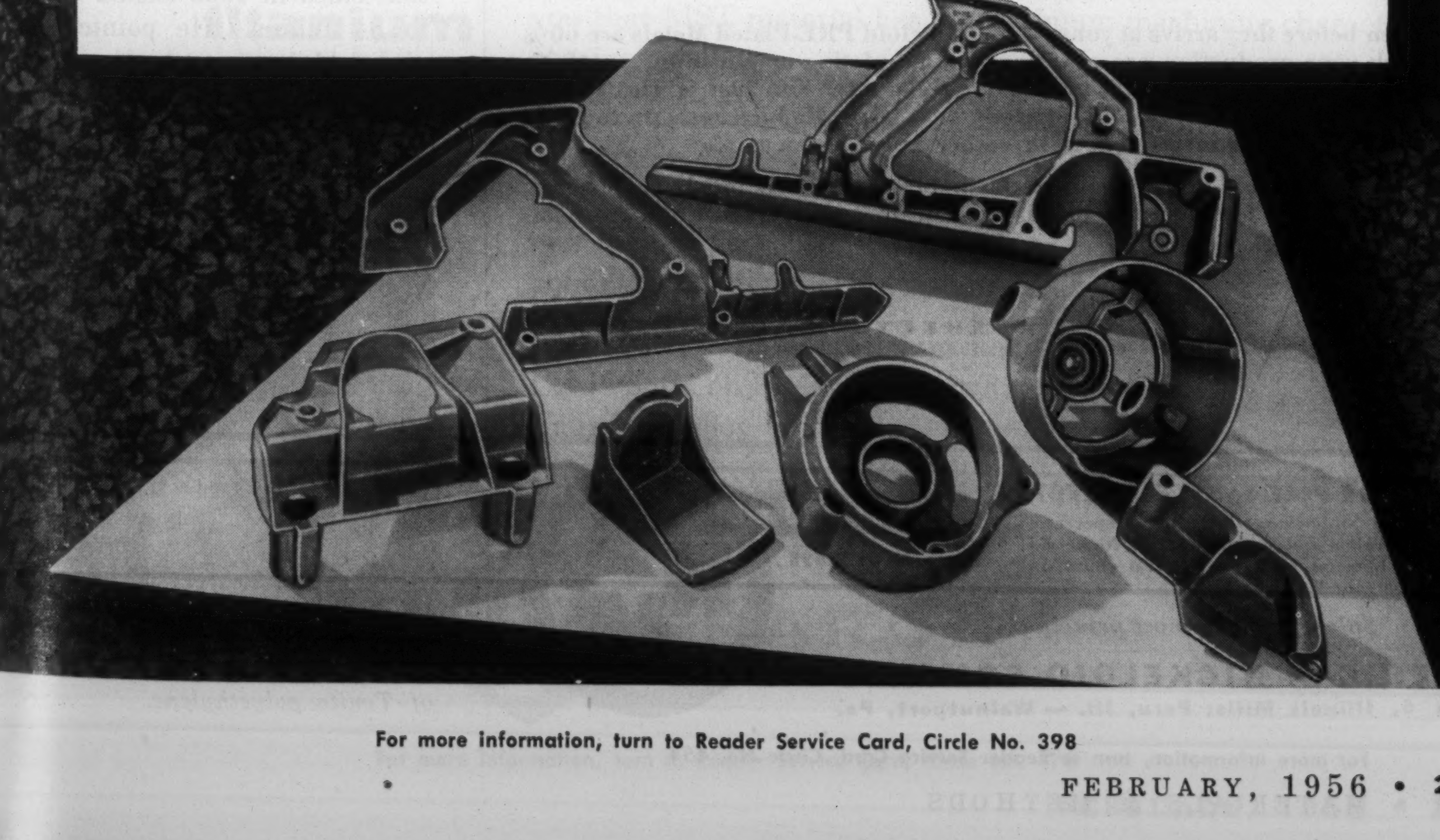

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MATERIALS ENGINEERING NEWS

Continued from p. 13

Another factor benefiting consumers is the rapid acceptance of substitute materials in nearly every segment of the manufacturing industry. Witness, for example, the conspicuous growth of the plastics and aluminum industries whose avowed aim is the invasion of new markets. As users obtain more performance data on these materials, this acceptance trend will continue, particularly in applications where shortages threaten to cripple production.

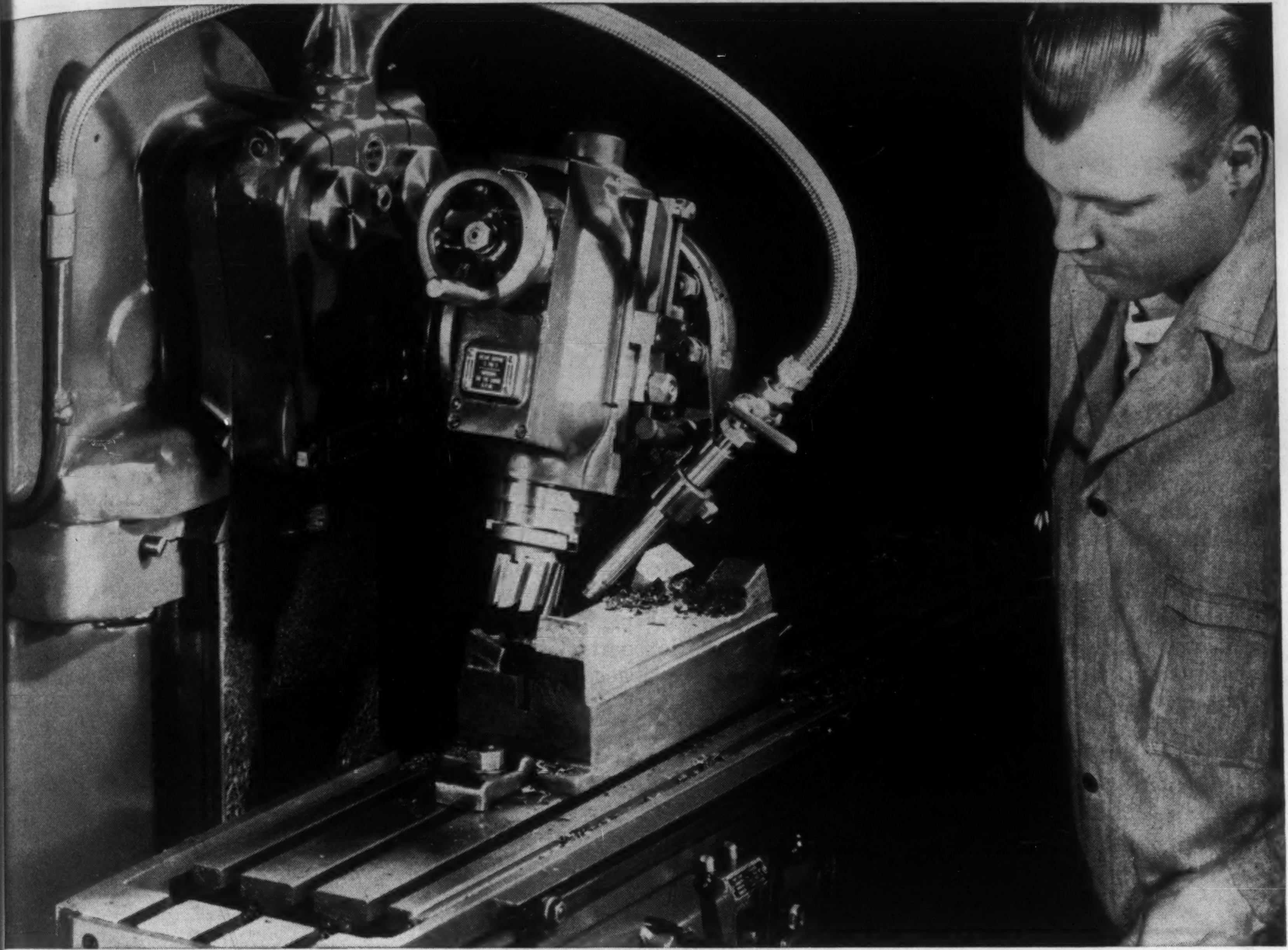
To the discerning user, willing to consider the entire range of available materials in his design plans, 1956 may well see an improvement in performance and appearance of his product at a lower cost.

Plastics

The plastics industry closed the year chanting a refrain about resin moons and cellulosic skys. The words were set to the very pleasing melody of a 3.6 billion pound production record with sales scaling up to $1.8 billion. All in all a 30% increase over 1954. Added to this was the optimistic note sounded by G. K. Frischer, president of Holiday Plastics Inc., that sales in 1960 should be close to $4 billion. He pointed to a nine-fold increase in the amount

Beauty and usefulness *are plastic attributes illustrated by this funnel of Tenite polyethylene.*

MALLORY-SHARON reports on TITANIUM



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accuracy

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exact

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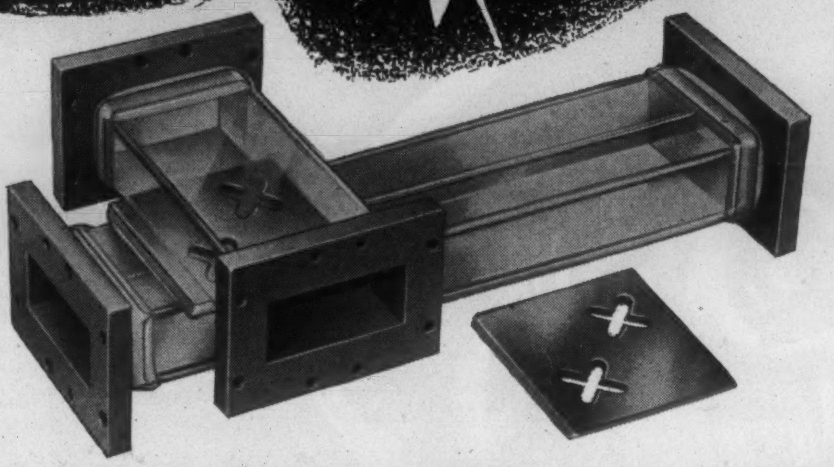

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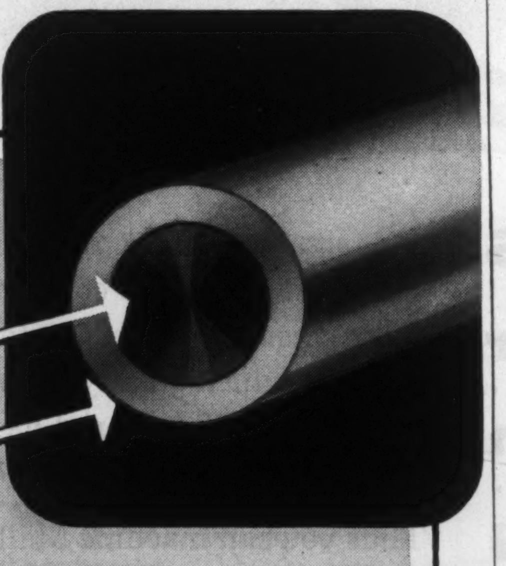

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of plastics used by the American family from 1940 to 1955, and predicted that in the next five years this should swell from the 83 lb per family in 1955 to about 152 lb.

A survey by the Society of the Plastics Industry, Inc., indicated that all plastics were involved in the big boom: phenolic molding, up 17%; cellulosic molding, up 20%; vinyl molding, up 25%, and polystyrene molding, up 27%.

Starring role was taken over by polyethylene which was up roughly 50% over 1954. Polyethylene is expected to reach 800 million to 1 billion lb by 1960. Its unique combination of properties is apparent from the consumption during 1955.

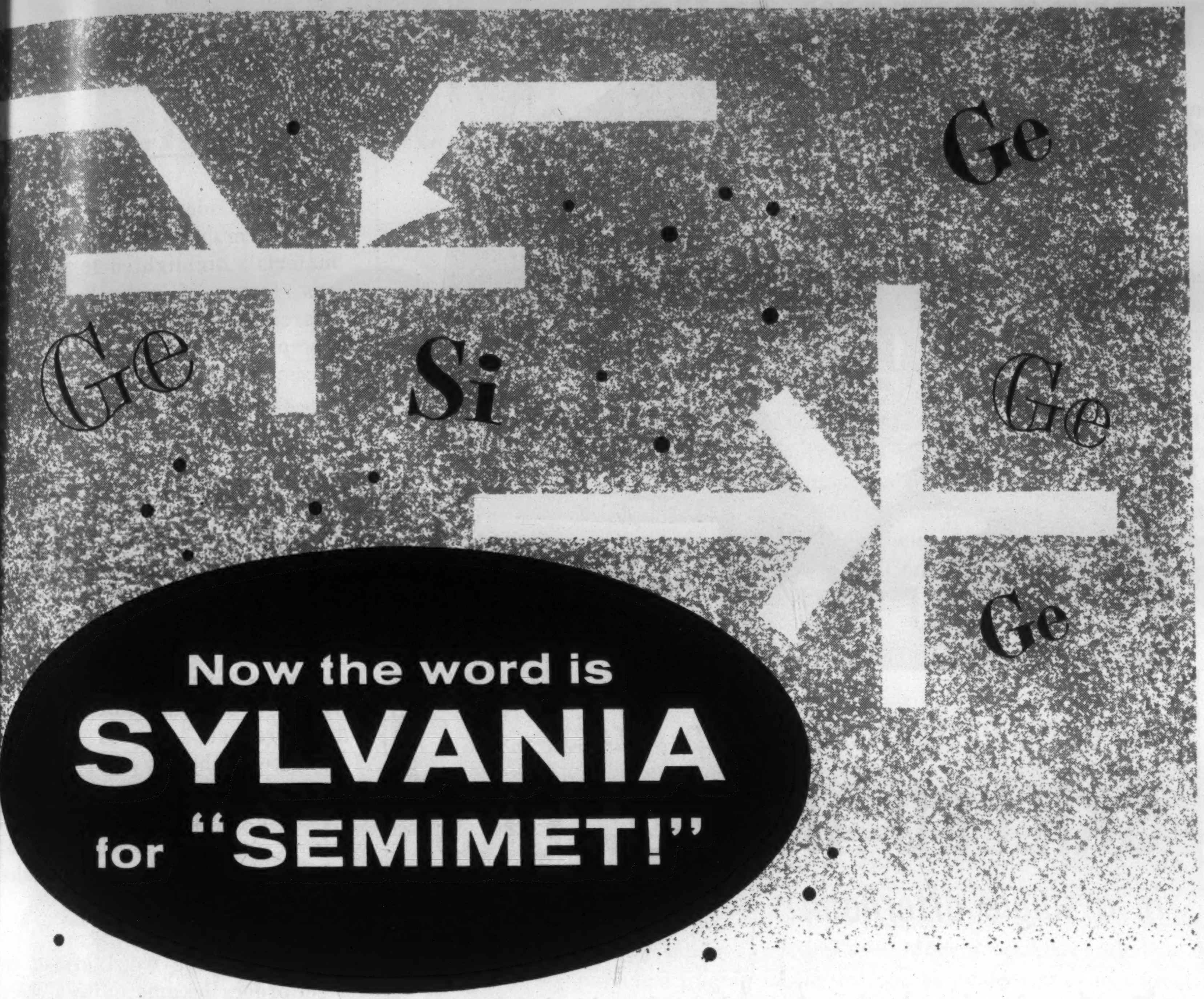
Film and sheet	125 million lb
Molding	60
Pipe	45
Electrical	40
Coatings	30
Bottles and tubes	10
Misc.	20
Total	330 million lb

In the reinforced plastics branch of the industry, use of polyester resin increased approximately 80% to an estimated total of 41 million lb. Vinyl film experienced a sales increase of around 20% in 1955 bringing the total resin used in its manufacture up to 85 million lb.

Applications—New applications of plastics were few in number during the past year with the emphasis on broadening uses developed in preceding years. A large part of the plastics increase was linked to production pace set in the automotive and construction industries.

Estimates of plastics use in cars range from 8 to 10 lb per car with every indication that this use will increase each year. The construction industry consumes plastics in nearly every phase of the building cycle, principally floor coverings, wire insulation, and laminates.

New techniques—On the manu-



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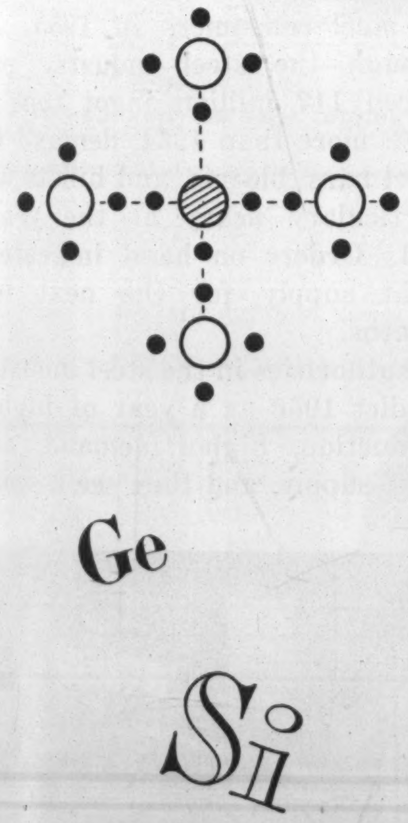

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Quality Control
INSTRUMENTS

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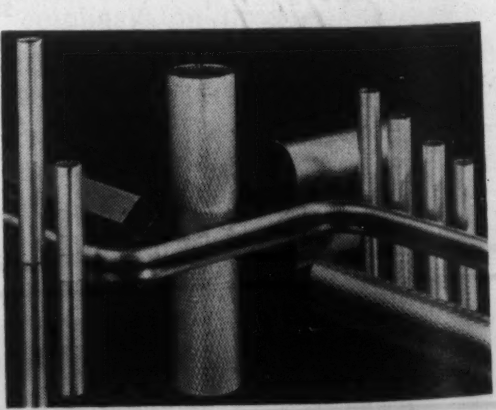
facturing side, new materials and new formulations of established materials highlighted 1955. Various forms of polyethylene appeared on the market and cellulose propionate was introduced on a commercial scale. Alkyds, epoxies, and fluorocarbons enjoyed increased applications in the field of plastics. Cellular foamed plastics also came into prominence in a wide variety of applications for cushioning, packaging, upholstery, insulation for clothing, safety devices such as padding in automobiles and aircraft, and other similar uses.

The use of matched metal molding in producing reinforced plastics products, coupled with the advance in the art of preforming, has speeded up the production rate and attracted a growing number of consumer product companies to this branch of the plastics industry.

Steel

Stamping the word *urgent* on steel orders became quite a chore to steel consumers in 1955. Although the steel industry produced 117 million ingot tons or 33% more than 1954, demand for steel bars, blooms, and billets was particulary heavy at the year's end. Orders on hand indicate a tight supply for the next few months.

Authorities in the steel industry predict 1956 as a year of higher production, higher demand, and tight supply, and they see a small



Steel leads *all other materials in production and variety of applications. Rigidized welded steel tubing is an attractive example.*

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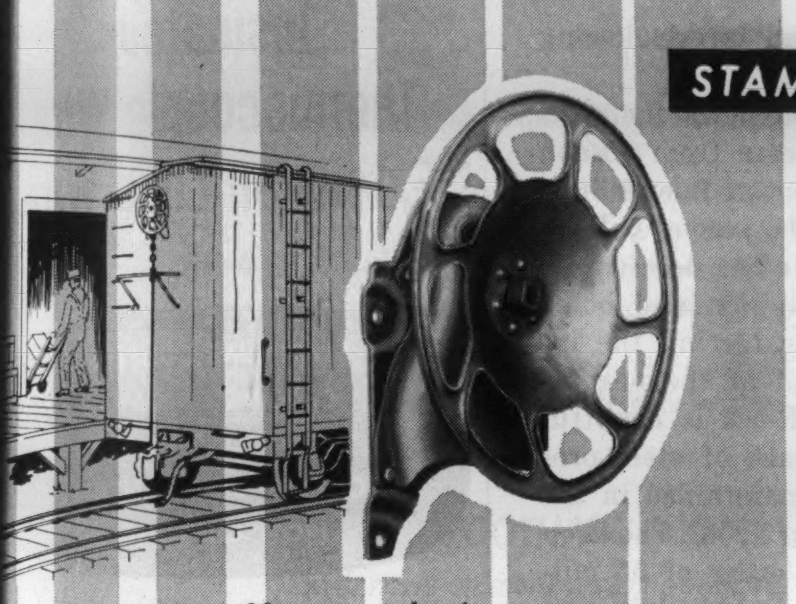

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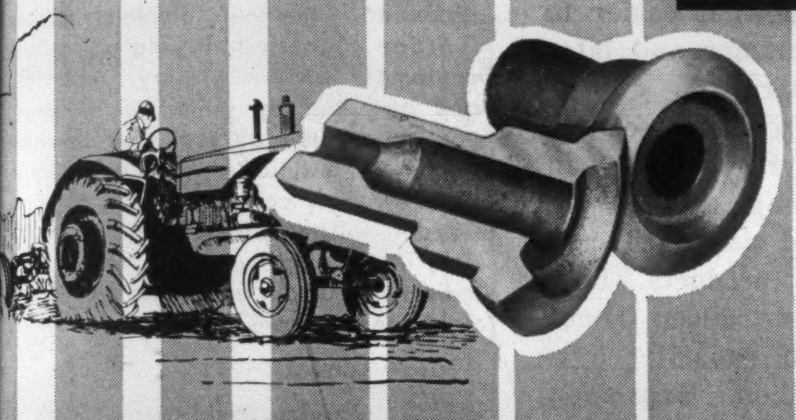

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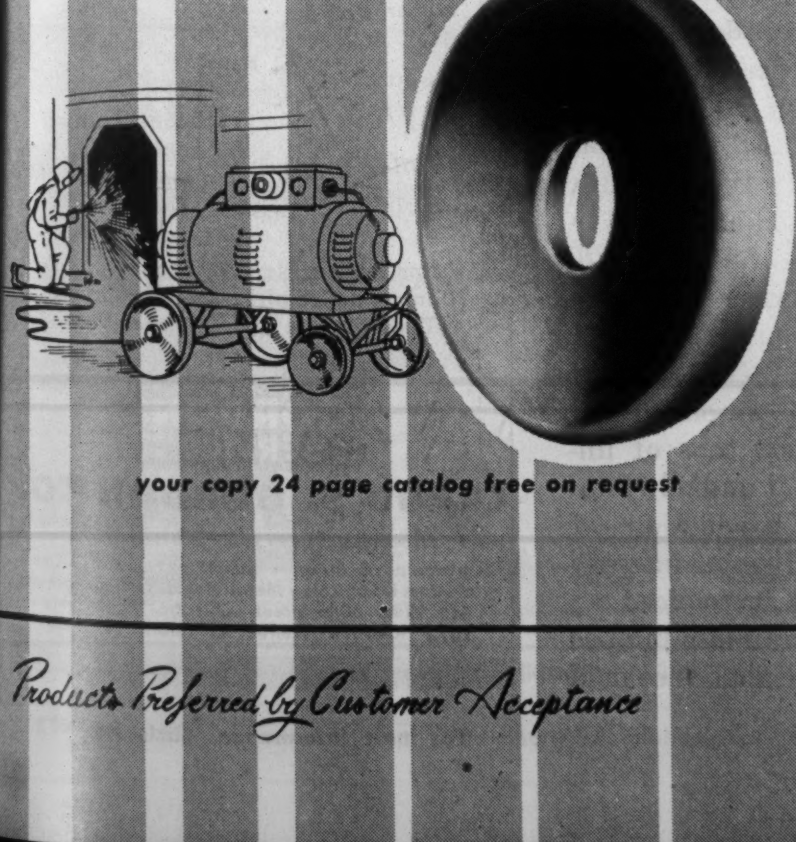

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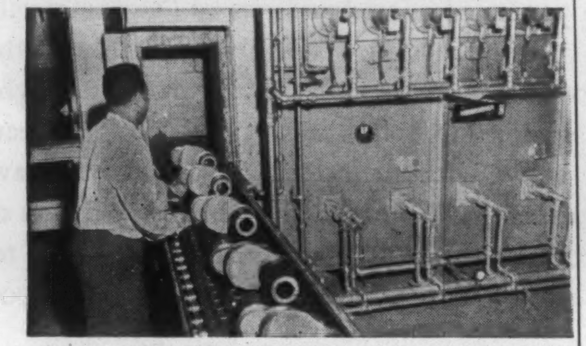

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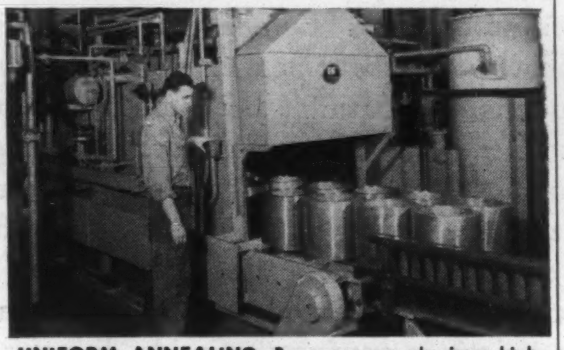

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MATERIALS ENGINEERING NEWS

but growing cloud foreshadowing a price increase.

But some good news for steel consumers did come from Joseph L. Block, president of Inland Steel Co., regarding the second half of 1956. Based upon the decrease in automotive production and home building, and considering the increase in demand of the heavier industries, Mr. Block is doubtful if the present pace of steel production will be maintained in the last six months of 1956. The drop would be on the order of 55 million tons which would make the combined total for 1956 very close to this year's level with an annual rate of 90 to 92% of new capacity. If this pattern should develop, steel will be somewhat easier to obtain in the summer and later months of the year.

Rumors of a price increase stem from projected investments in adding steelmaking capacity to meet the expected rising per capita uses of steel products. Last year the industry added about 2,534,780 tons of capacity at a cost of $700 million. Expansion and modernization during 1956 is expected to total up to $1 billion.

Ben Moreel, Chairman of the Board of Jones & Laughlin Steel Corp., forsees the need for 30 million ingot tons of new steelmaking capacity over the next 10 years. He indicated, however, that rapid expansion of this order made a further price increase of steel mandatory.

Stainless, electrical and tool steels — This year the stainless steel industry turned out approximately 673,000 tons of finished mill products, a 49% increase over 1954 production. In the opinion of E. J. Hanley, president of Allegheny Ludlum Steel Corp., shipments by 1960 will be 800,000 tons of finished products. A not unlikely total considering that production of stainless steel has doubled in every decade since it was introduced.

Consumption of stainless jumped 60% in the domestic appliance field

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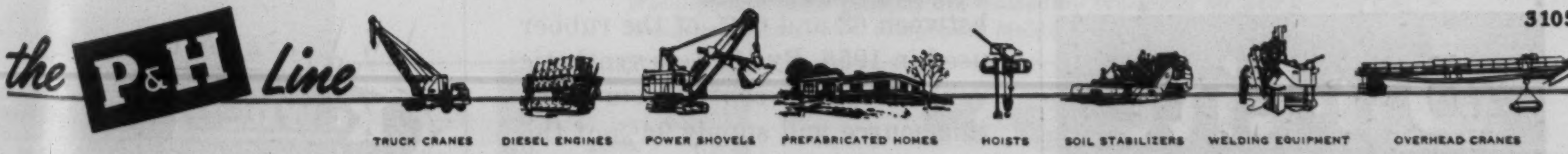
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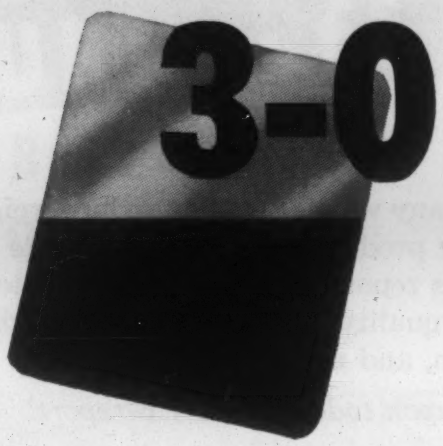

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MATERIALS ENGINEERING NEWS

and building hardware firms are increasing their items made of stainess steel. Other growth fields are the automotive markets with pounds of stainless used per car on the increase and in architecture with the rapid acceptance of stainless as a building material.

Electrical steels used in generators, motors, transformers, and other electrical equipment were up 785,000 tons from the 589,000 tons produced in 1954. The tool steel market continued high with 112,000 tons produced. Production outlook for this material is optimistic due, in large part, to the major retooling of the automotive industry.

Specialty steels — Commercial production of specialty steels increased to approximately 3500 tons in 1955. Vacuum melting, induction melting, and consumable arc melting facilities were added by various companies to supply the demand for alloys of high purity and unusual physical and chemical properties.

Principal markets for specialty steels continue to be in the nuclear, aircraft, and guided missile fields with a growing consumption in instruments and automatic control devices. Still in the expensive baby stage, specialty steels are expected to double their productive capacity in 1956.

Rubber

Last year rubber consumers had little choice but to pay the price demanded by Far Eastern speculators who doubled the cost of natural rubber in a little less than 10 months. However, their situation promises to take a new turn in the next five years. Big reason is the increasing use and improvement in synthetic rubber.

Accounting for 60% of the rubber consumed in 1955, use of synthetics is expected to increase to between 62 and 65% of the rubber used in 1956. By 1960, as synthetic rubber capacity continues to grow, this source will supply 94% of the total rubber consumed. As a consequence, that year will see a world

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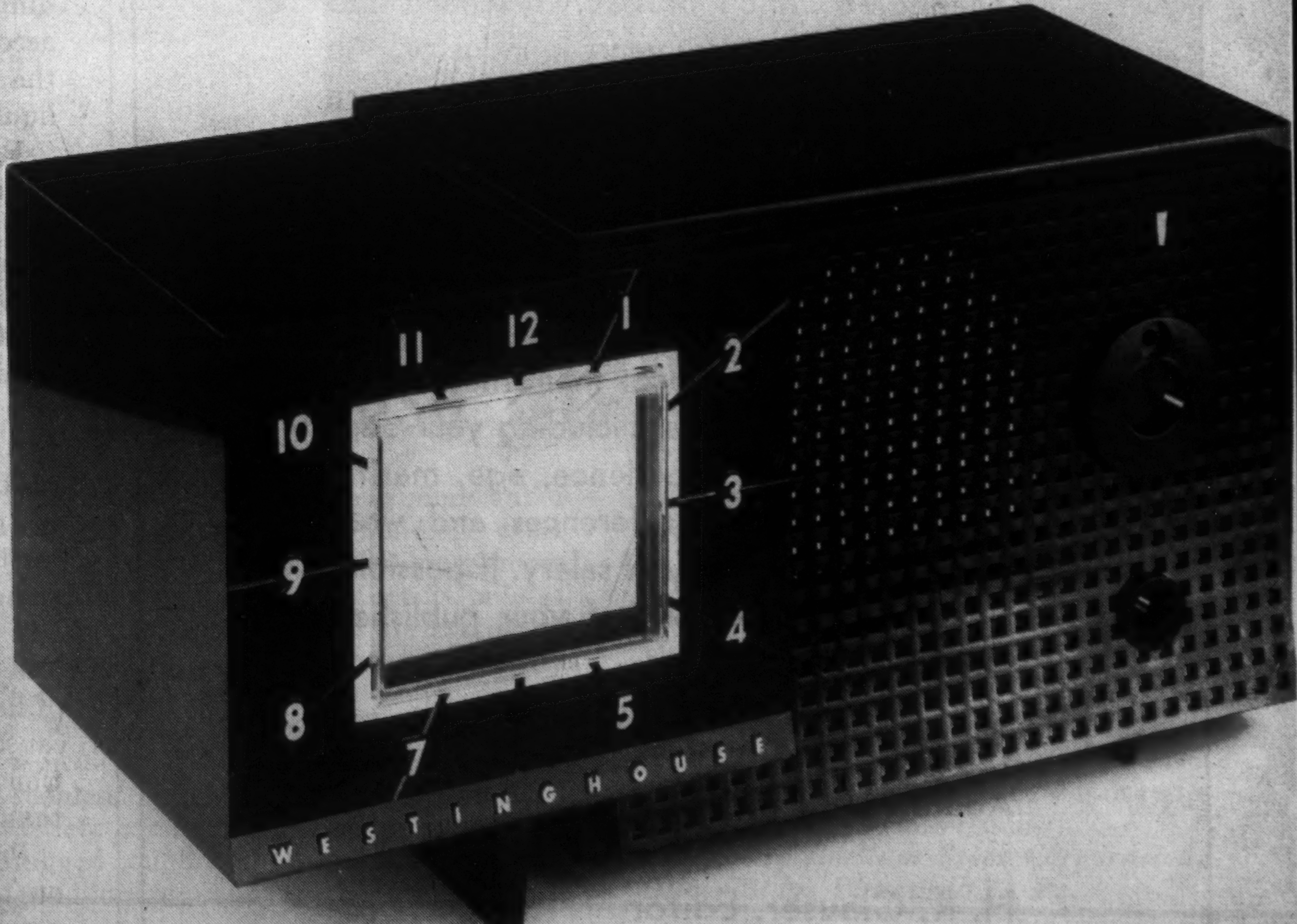

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MATERIALS & METHODS

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MATERIALS ENGINEERING NEWS

excess of 330,000 tons in new rubber with natural rubber production only 4% higher than it was in 1955.

Non-tire production — The volume of business in non-tire production passed the $2 billion mark for the first time in 1955. Thomas Robins, Jr., president of Hewitt-Robins Inc., looks to an increase of 5% in the sales volume in 1956, representing 53% of the rubber industry's total sales.

Non-tire rubber products sales have grown faster than tire sales and this trend gives every indication of continuing as new products are developed. Conspicuous in this segment of the industry were latex foam products of all types which have had a spectacular growth in the past ten years. With their wider use in automobiles and buses and an expanding use in the bedding and upholstery fields, foams accounted for a large proportion of the estimated 160,000 tons of liquid latex consumed in 1955.

Production of belt, hose, molded and extruded goods, and flooring was sparked by the high level of home construction. The production curve for these products was paralleled in hospital goods and rubber sundries in the field of infants' and sports goods.

An estimated 560,000 tons of rubber will be used in non-tire rubber products in 1956, about 38% of the total rubber expected to be consumed in the U.S. However, nontire products as a group require less raw rubber per dollar's worth of finished goods manufactured because they contain a higher proportion of textiles and other materials than do tires.

Price structure—Closing prices on the Commodity Exchange for natural rubber in the grade of No. 1 ribbed smoked sheets ranged from 29¾¢ to 52¢ per lb between Mar 8 and Dec 5, 1955. By contrast, general purpose synthetic continued to hold to its three year old price of 23¢ per lb. Last year's 52 cent price of natural rubber

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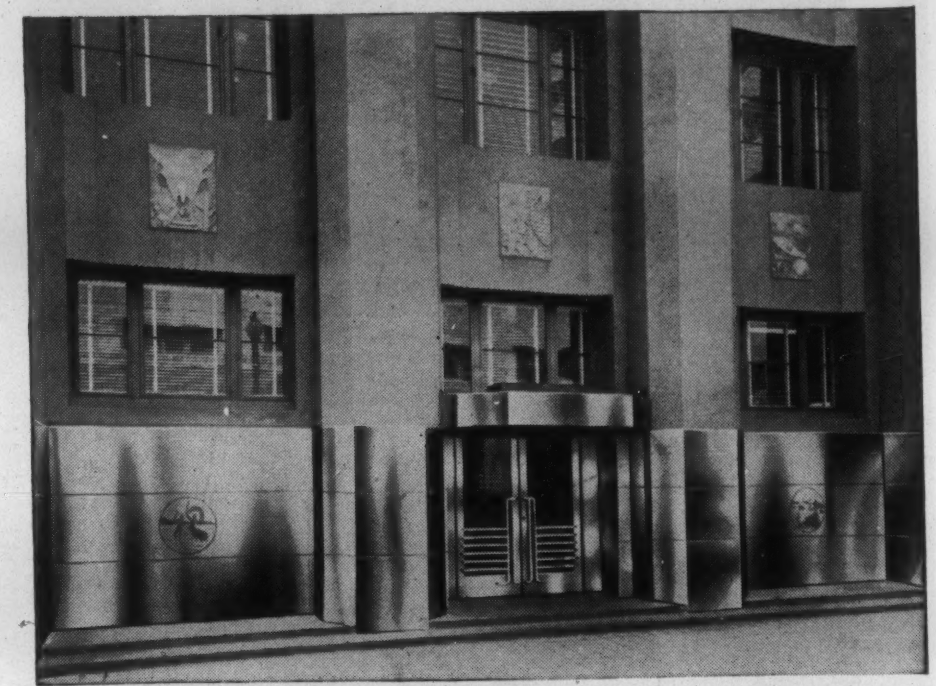

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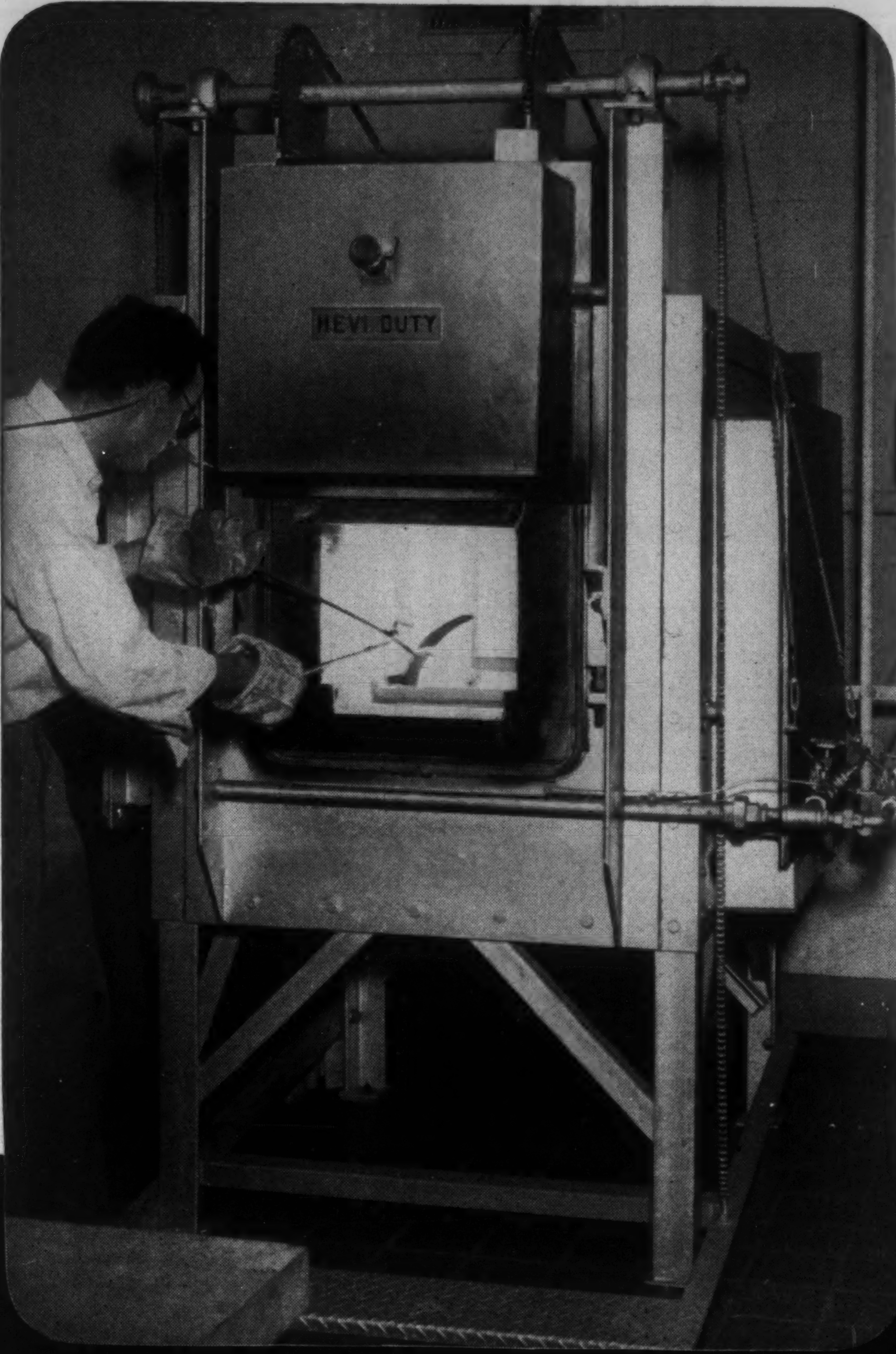

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was as high as that of Jan 1952 when the market was influenced by the Korean War. The price can be compared with a range of 19½ to 34⅜¢ in 1954, 19⅞ to 32¢ in 1953, and 26½ to 52¢ in 1952. A record was established Nov 8, 1950 when the price zoomed to 85½¢ per lb.

Engineering developments – During 1955 three major rubber companies announced their methods for the synthesis of natural rubber. The first information came from B. F. Goodrich with the statement that their new rubber does not contain styrene or butadiene and is an exact duplicate of tree rubber. Although it is claimed that the raw materials are in ample supply in this country, the specific reagents have not been disclosed by Goodrich. Known as Ameripol SN, the new product is said to possess all the physical properties of tree rubber down to the traditional stickiness. X-ray patterns show a close similarity between Ameripol SN and the tree rubber.

Firestone then revealed that a pilot plant has been producing their new product for three years. The new rubber, called Coral Rubber, is characterized by gum tensile strength (about ten times that of cold GR-S and about 90% that of natural rubber), low hysteresis (heat buildup), and good retention of properties at high temperatures. The cracking resistance and thermal stability of stocks made from this new synthetic are claimed to be superior to those of natural rubber, attributed to a slight difference in structure which makes the new rubber more resistant to oxidation.

Hard on the heels of these announcements, Goodyear released information on the synthesis of a polyisoprene having a structure very similar to that of Hevea natural rubber. The X-ray pattern shows a close similarity to the natural product; however progress on the evaluation of this development is still insufficient to be able to state just how closely the physical properties and performance of this new polyisoprene will duplicate the natural product.

Structural adhesives

Use of structural adhesives more than tripled in the U.S. during 1955. C. W. Brown, vice president and general manager of Narmco Resins & Coating Co., estimated that upwards of a quarter billion dollars of aircraft components were bonded by adhesives. Principal factor in airframe utilization has been the use of sandwich components made of a lightweight core faced with thin metal faces.

Consumption of adhesives for bonding sandwich components should show a tremendous growth in commercial construction. During 1955, almost a million square feet of lightweight, sandwich paneling employing structural adhesives were used in the construction of office buildings, factories, hotels, and other commercial buildings.

Last year also saw the development of structural adhesives capable of performing with uniform reliability at temperatures ranging up to 500 F. This marks a continuing improvement as evidenced by an operating limit of 250 F for adhesives three years ago while five years before the adhesive heat barrier was only 180 F.

Nickel

Most nickel consumers ended up 1955 in a wistful mood. Shortage of nickel was a plague to the industry during the year with some consumers forced to curtail operations. This unrelieved condition brought the gray market back with prices as high as \$2.50 per lb as compared with the regular market price of 64½¢ per lb.

Seriousness of the shortage was highlighted when the government announced plans to study the situation and the future supply outlook. Appointed to task by the Office of Defense Mobilization, J. R. Townsend, Director of Materials and Standards Engineering, Sandia Corp., will analyze all government

Cambridge

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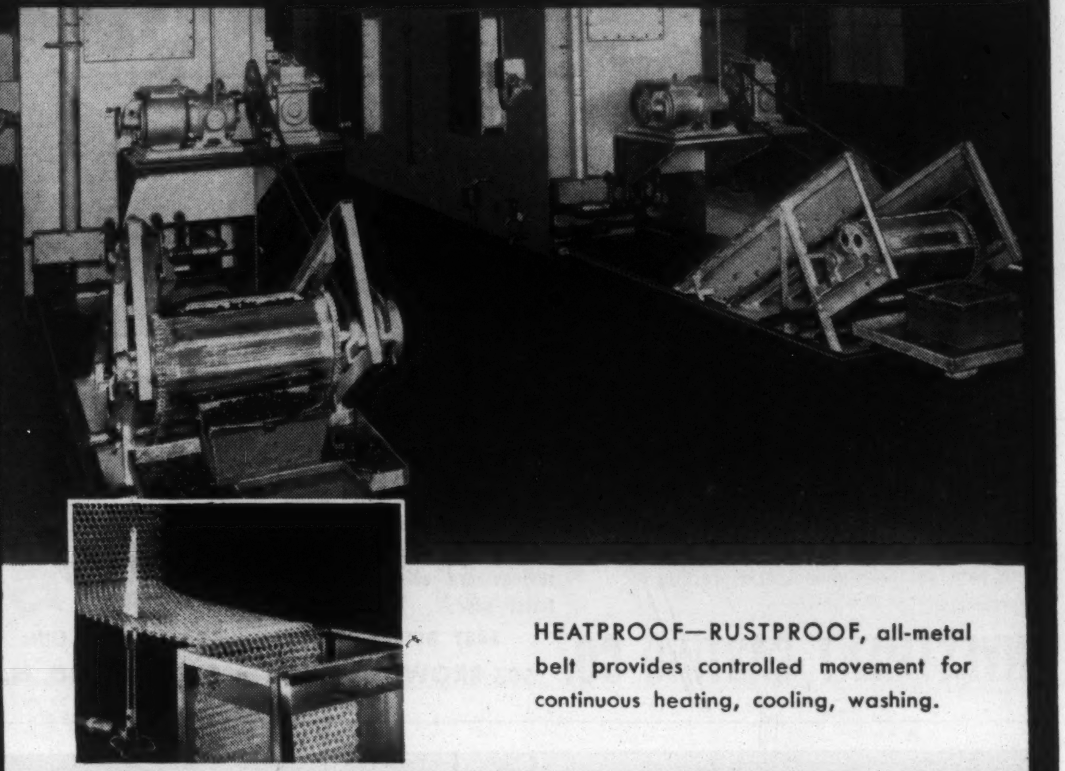

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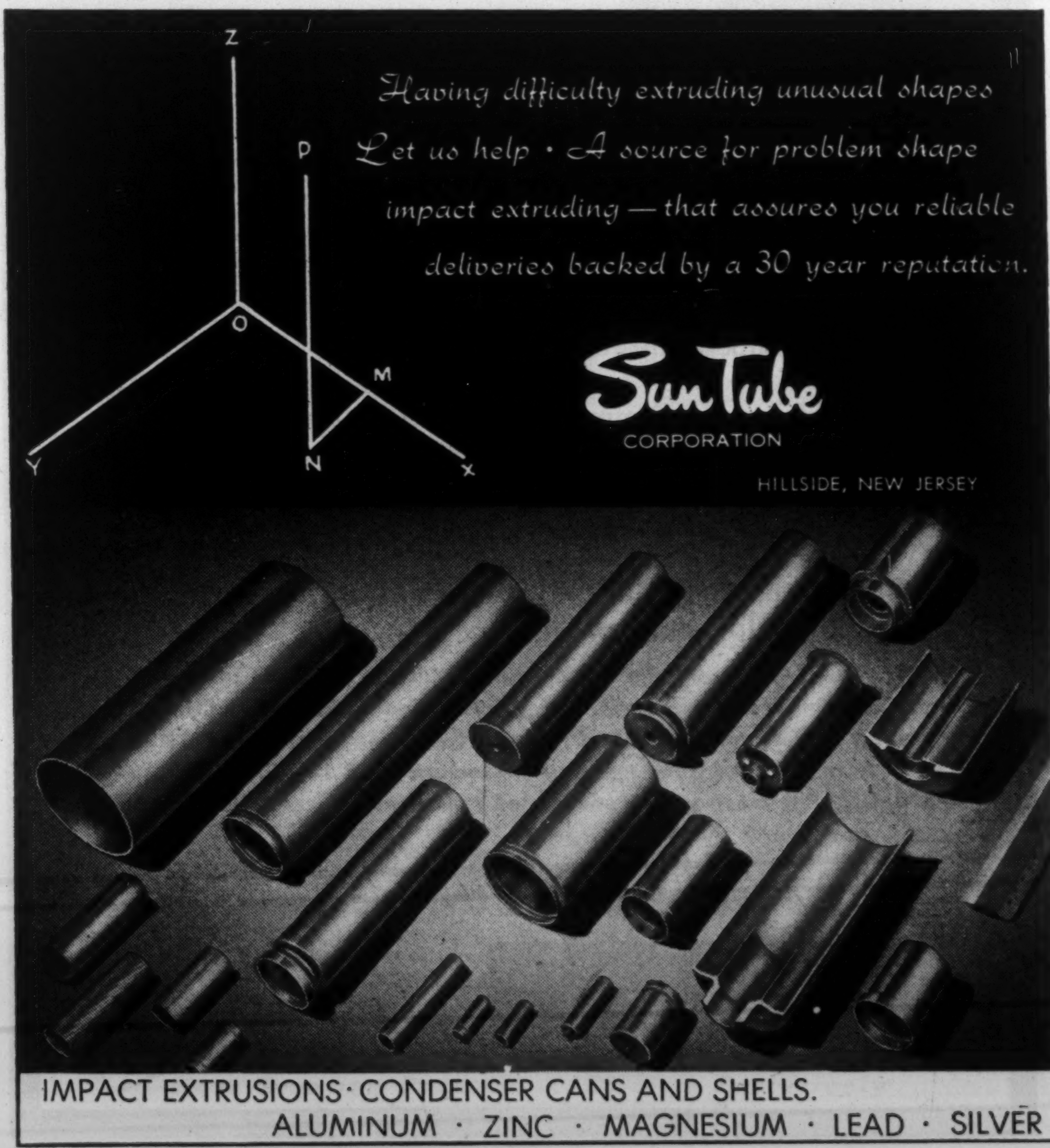

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activities relating to nickel including stockpiling and expansion plans.

In line with conserving this vital defense metal, the American Iron and Steel Institute introduced Types 201 and 202 steel during the past year. Both have a lower nickel content and apparently equal the chemical and physical properties of the higher nickel austenitic types. These steels also appear to have higher mechanical properties.

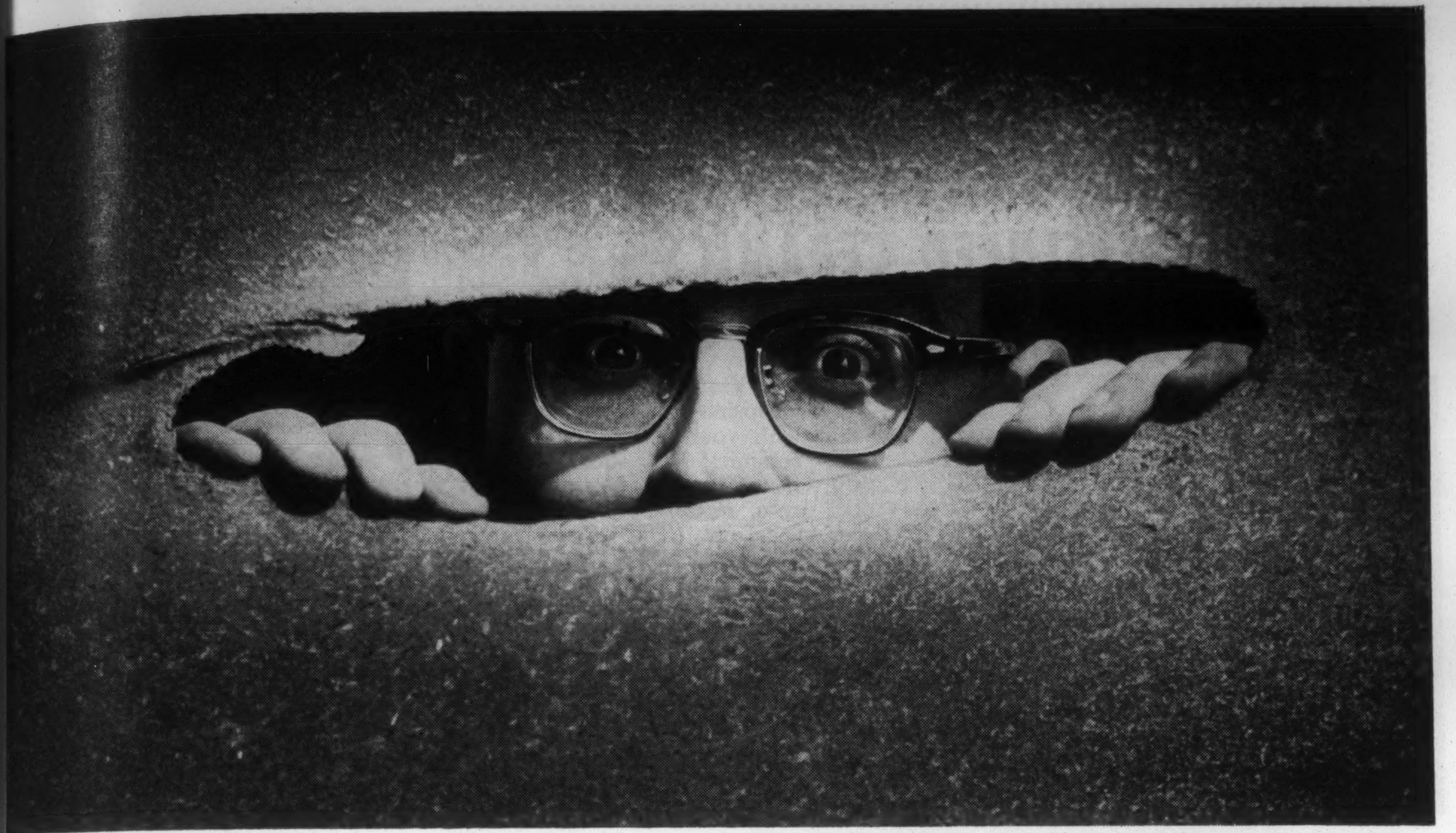
Nickel producers of the free world increased output more than 10% to a record of 427 million lb according to John F. Thompson, chairman of the board of International Nickel Co. of Canada, Ltd., Canada was the leading producer contributing 81% of the total. The U. S. consumed two-thirds of the free world total with one-third going to other portions of the free world. Nickel production is expected to increase to 442,000,000 lb in 1956 with more of it available for industry.

Price of nickel in all world markets remained unchanged at 64½¢ (including the 1½¢ U.S. import duty). Substantial assistance in combating gray market prices was provided by the U.S. Government in diverting to industry approximately 24 million pounds of scheduled stockpile purchases of nickel.

Principal consumption was in the production of chromium-nickel stainless steels, engineering alloy steels, nickel-chromium alloy castings, cupro-nickel alloys, and various nickel-chromium alloys. All other nickel consuming industries also showed great increases including the nickel-plating industries, chemical industries using nickel as a catalyst, and ceramic and electronic industries utilizing nickel compounds.

Titanium

Titanium, the wonder metal, continues to be a source of wonderment to metal consumers. Besieged by literature expounding the superiority of titanium, the average consumer is caught in the vise of



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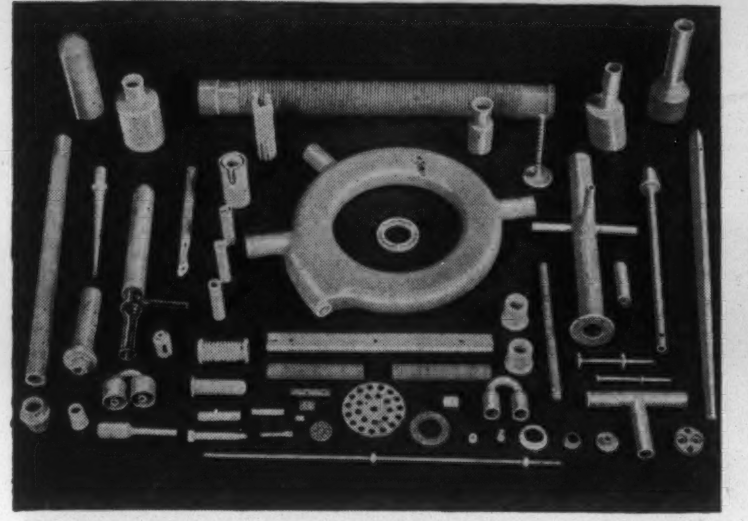

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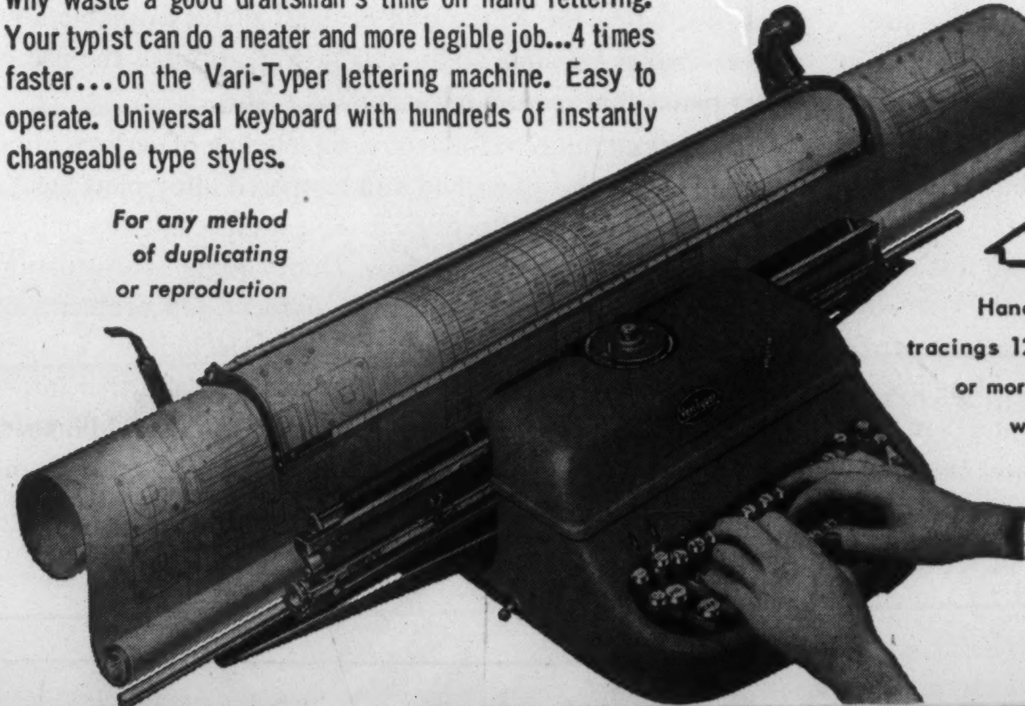

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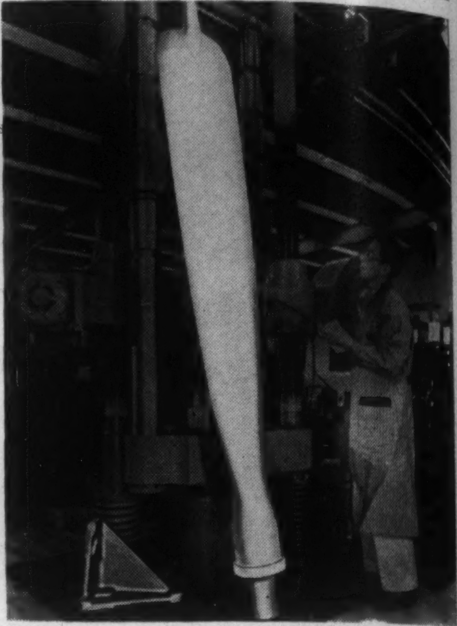


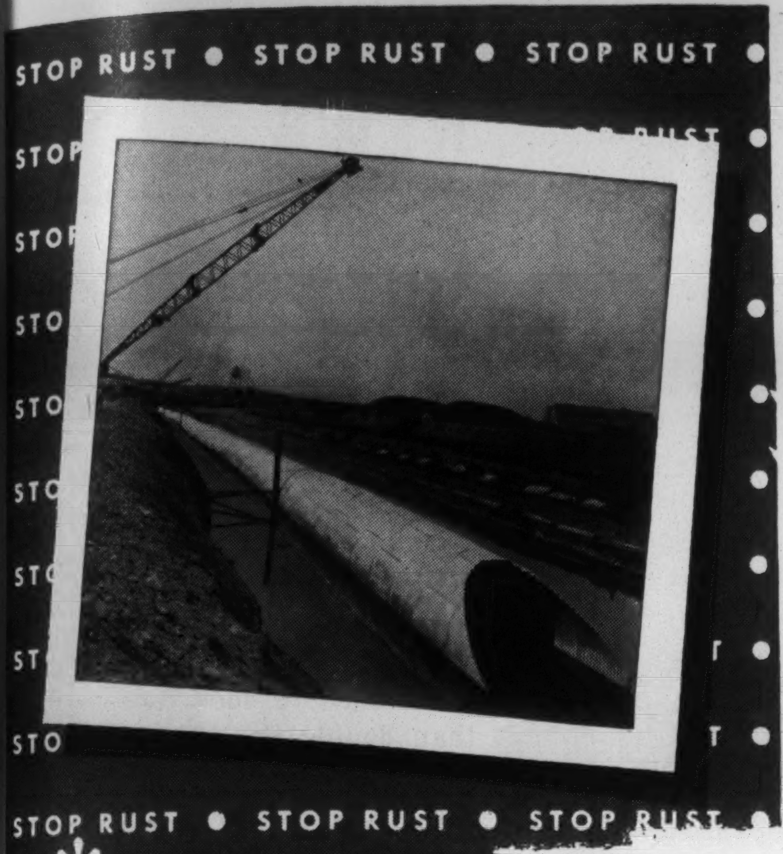
***Use in military aircraft** during 1956 is expected to double last year's production of titanium.*

high metal cost and lack of rigid property standards.

On this subject, C. I. Bradford, president and general manager, Rem-Cru Titanium Inc., listed the following resolutions for 1956: continuance of quality improvements, further alloy development, and advancing the industrial use of titanium. With regard to the latter, he pointed out that industrial consumers are assured of a supply of metal by the Department of Commerce order M-80 which allows the producer of mill products to channel up to 10% of his output to non-defense applications.

Cost being the greatest single deterrent in non-defense industrial use, the titanium industry has made a special effort to breach this barrier. In 1955, sponge declined about 23% and finished mill products an average of 19%. On April 1, Titanium Metals Corp. of America cut 55¢ off the $4.50 sponge price and lowered mill products from $1.00 to $3.00 per lb. On November 1, DuPont announced a 20¢ per lb additional sponge reduction, and three weeks later Titanium Metals Corp. cut the sponge selling price an additional 30¢ per lb. (to $3.45 per lb) and again reduced various mill products from 80¢ to $3.50 per lb.

T. W. Lippert, manager of technical service, Titanium Metals Corp. of America, estimated the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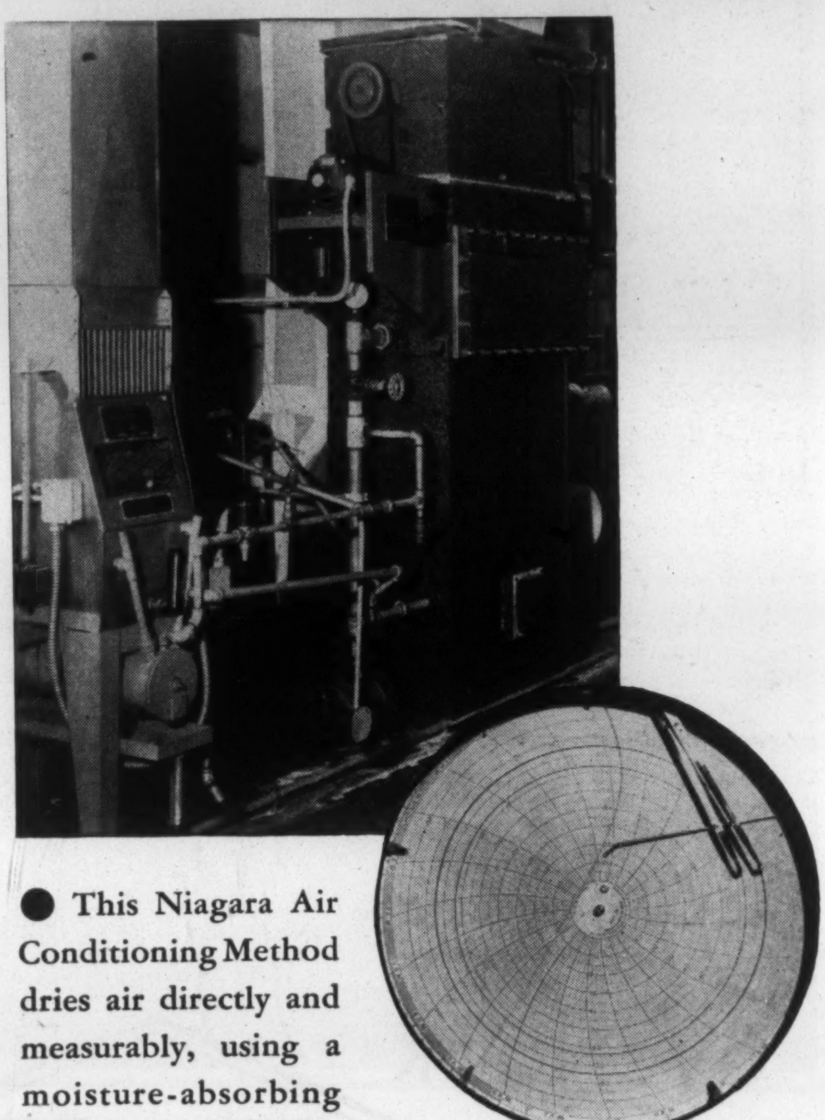

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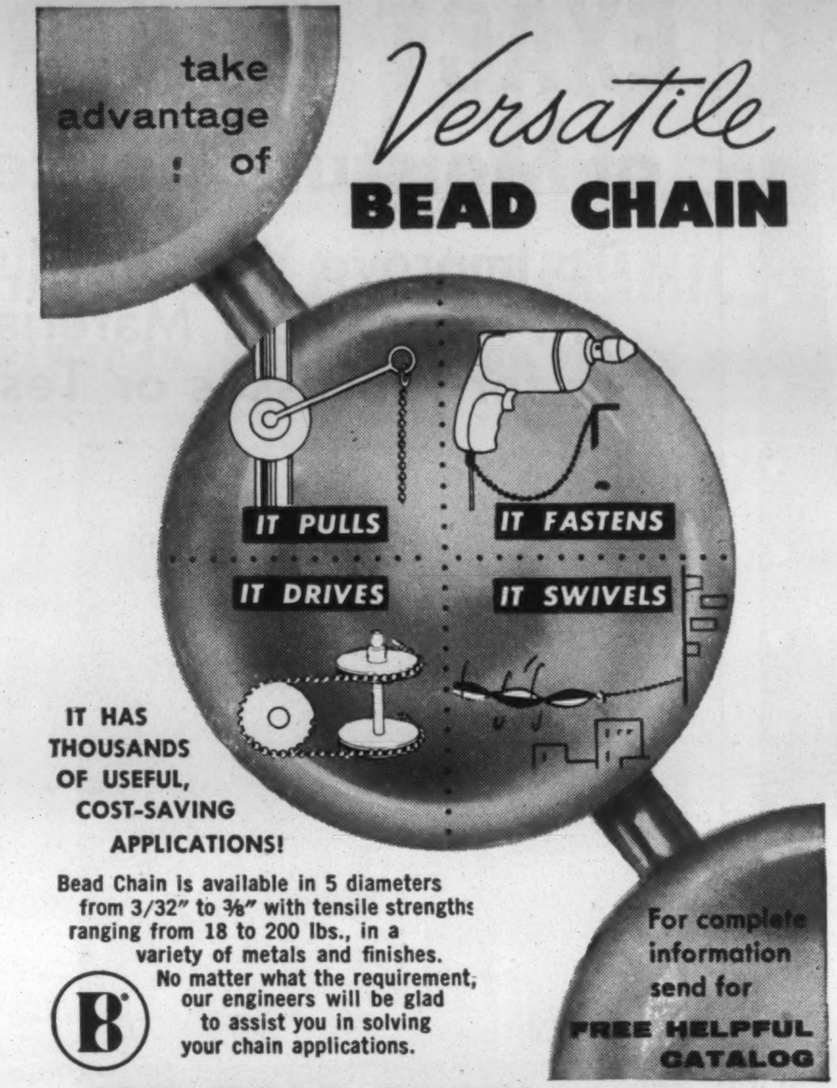
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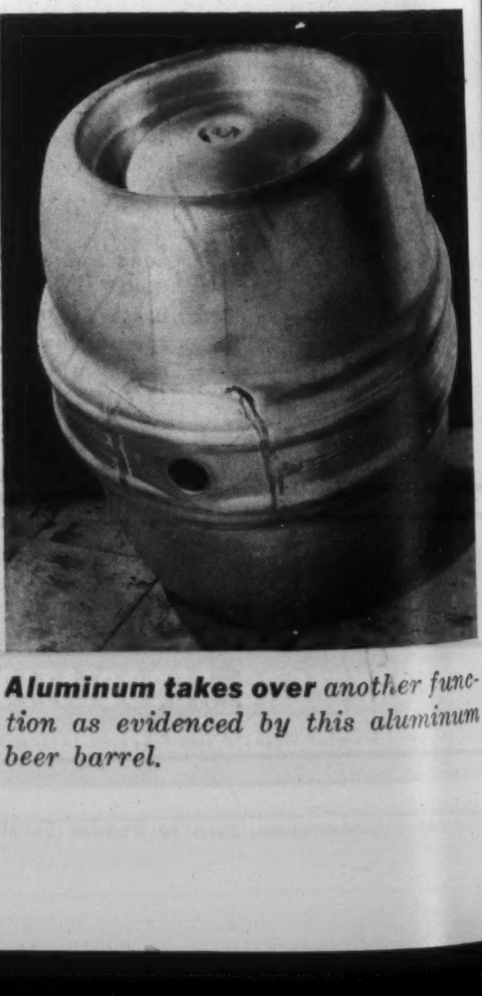
dollar value of mill products in 1955 to be on the order of $60 million with sale of sponge accounting for an additional $30 million. Production of mill shapes is estimated at 1900 tons for 1955 divided about 54% sheet and strip and 46% bar, billet, and extrusions. Current Government estimates show probable 1956 requirements for mill products ranging from 4000 to 4500 tons or more than double the 1955 production.

Aluminum

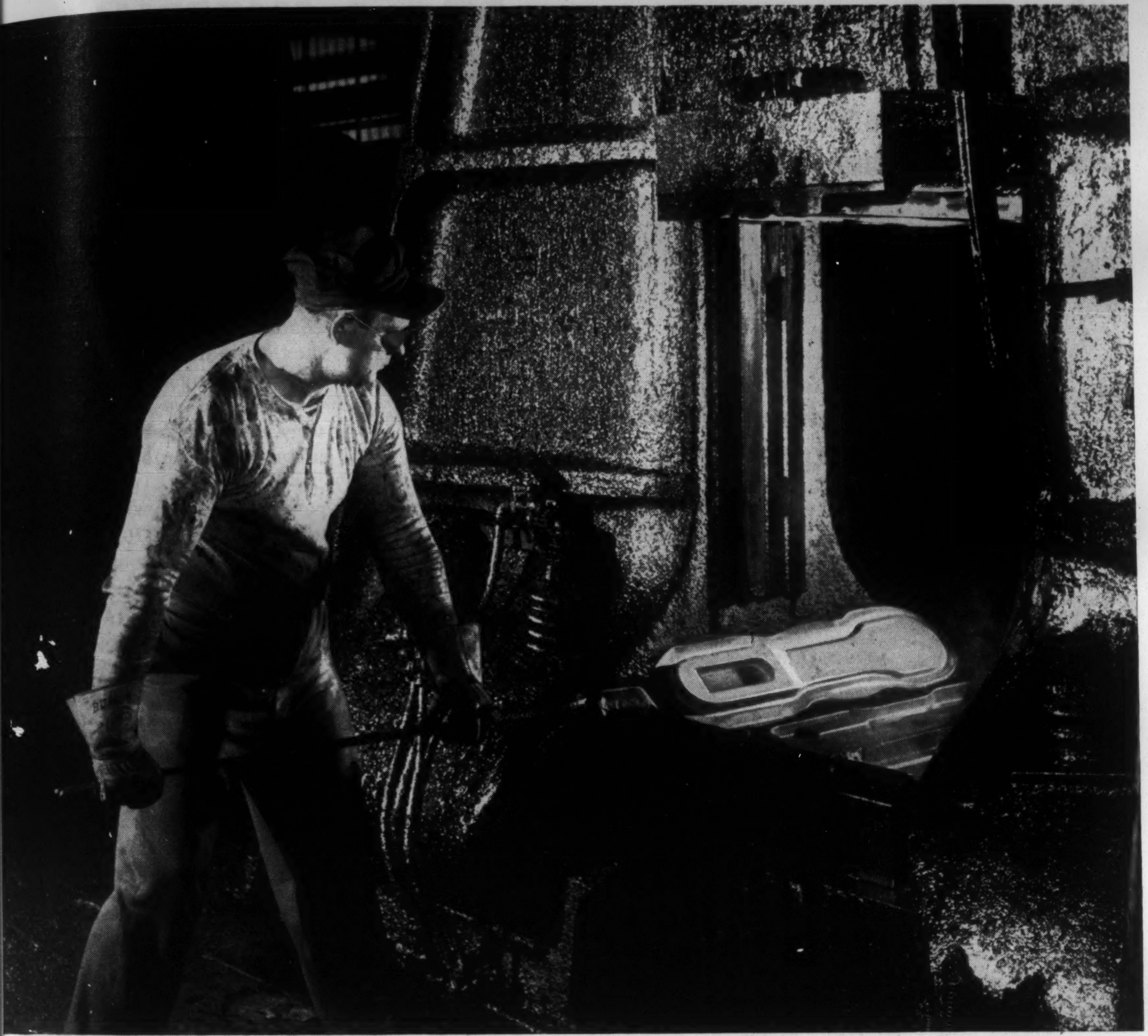
Continuing its aggressive expansion in 1955, the aluminum industry supplied an estimated 3.1 billion pounds of primary production with every indication of bringing production up to 3.3 billion pounds in 1956. Despite this record output the metal was in tight supply during the year, a condition partly relieved by the government's action in diverting to industry substantial quantities of aluminum from stockpiling calls.

Two price increases marked 1955 raising the base price of primary aluminum up to 22.5¢ with corresonding increases in the prices of most fabricated aluminum products.

Noteworthy developments in the



***Aluminum takes over** another function as evidenced by this aluminum beer barrel.*



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Versatile... New Coating Method Fuses Corrosion Resistant Plastics To Metal And Other Plastics

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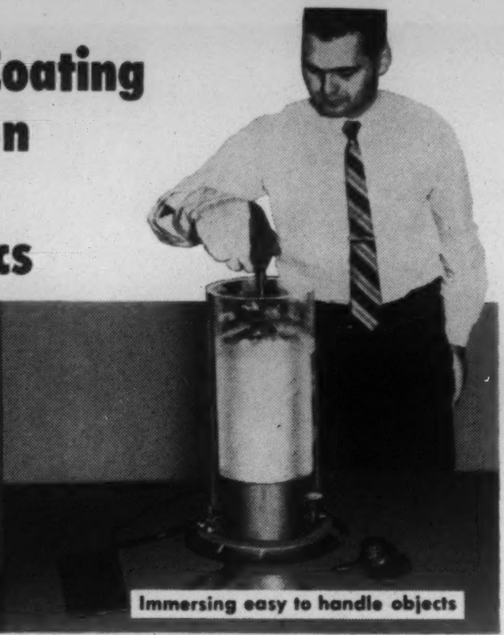

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application of aluminum were in the building and electrical fields. In electrical use particularly was the inauguration of a development program to use aluminum wire in communication cable and the production of aluminum strip which is self-insulating as a result of special anodized treatment. New gains were also registered in the use of aluminum in automobiles. One of the latest models uses 197 lb per car as contrasted with the average use of aluminum 10 years ago of less than 10 lb per car.

Copper

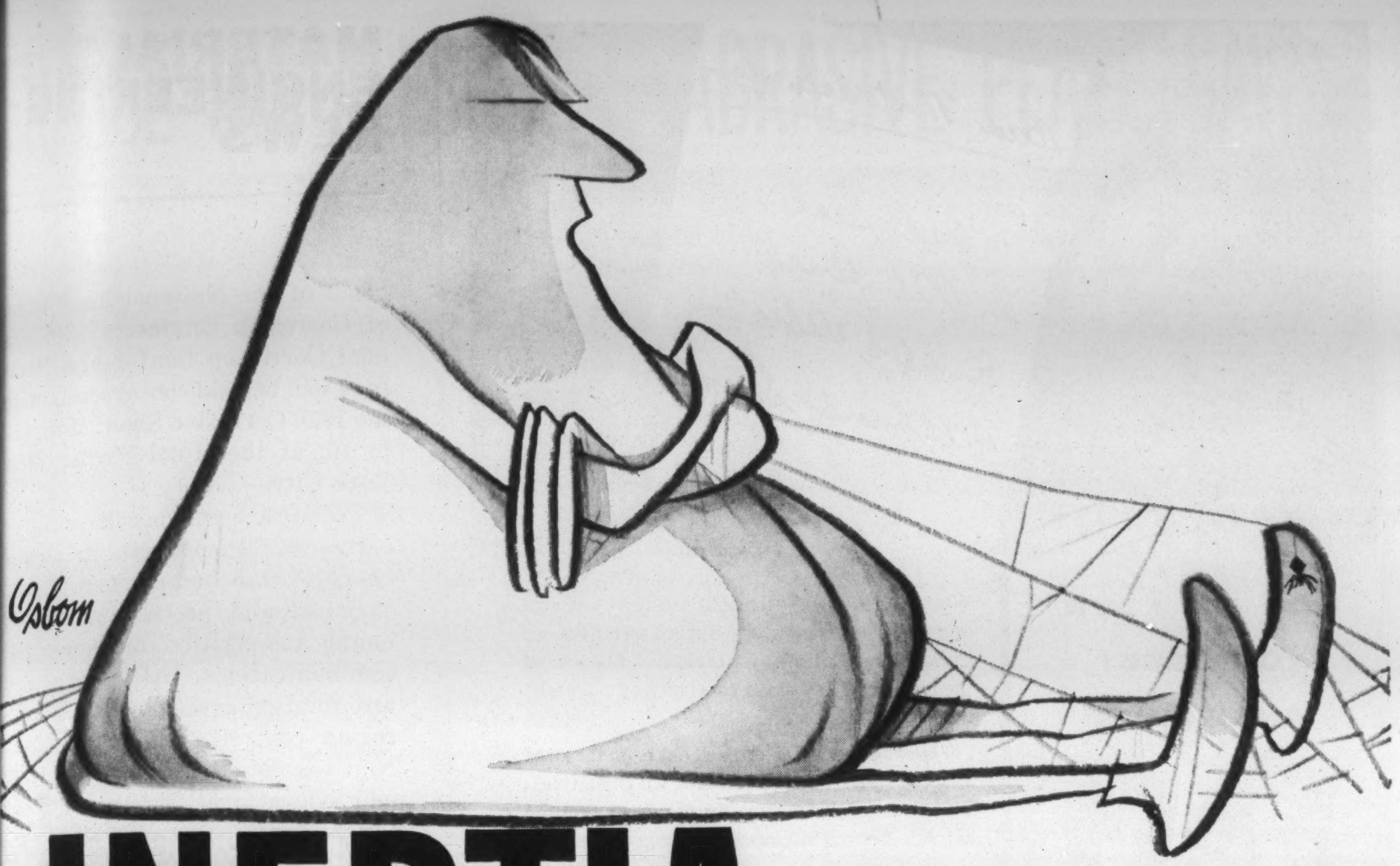
The most detrimental factor to the copper industry during 1955 was the occurrence of strikes in the three major copper mining countries—U.S.A., Rhodesia, and Chile. Supply of copper would have balanced demand in 1955 except for these labor disturbances. One estimate places the loss of production during 1955 at 12,000 tons of copper per month. The immediate effect was to cause a world-wide tight copper market.

The unprecedented world demand for copper coupled with low level domestic prices caused a flow of copper away from the U. S. Although approximately 85,000 tons of copper intended for stockpiling were made available by the government, the supply of copper was still insufficient to meet consumer requirements.

Provided there are no major strikes to disrupt production, the copper industry expects to attain a rough balance between supply and demand sometimes during 1956. If production is unimpaired, output of refined copper for 1956 will reach a new record of 3 million tons for the free world. This would be approximately 10% over 1955 production of 2.7 million tons.

Corrosion Engineers Will Meet in NYC

Corrosion problems in industry and what is being done to solve them makes up the technical pro-



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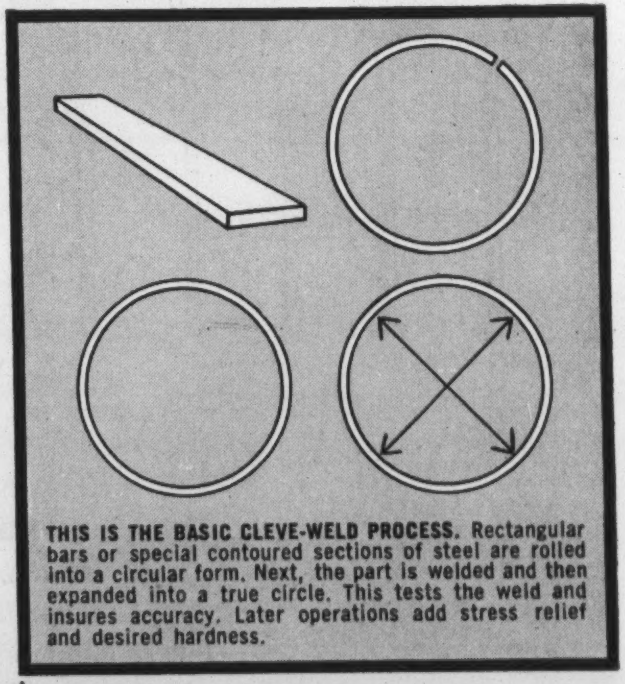

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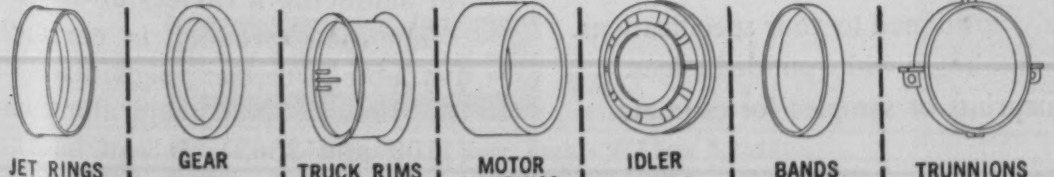

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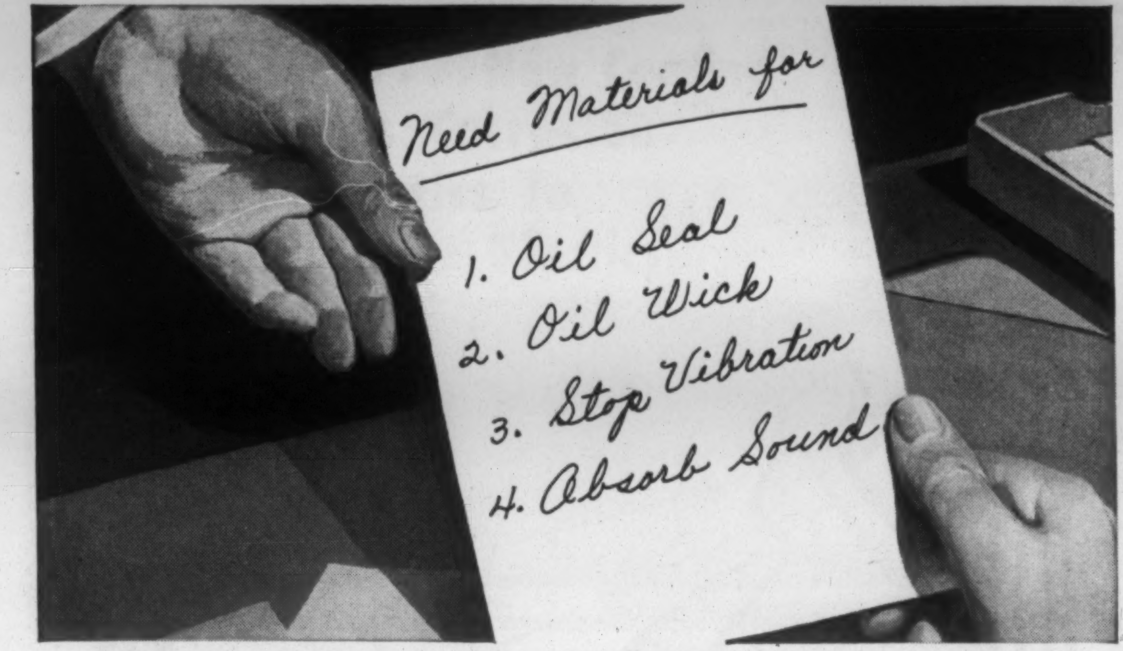
For more information, turn to Reader Service Card, Circle No. 359



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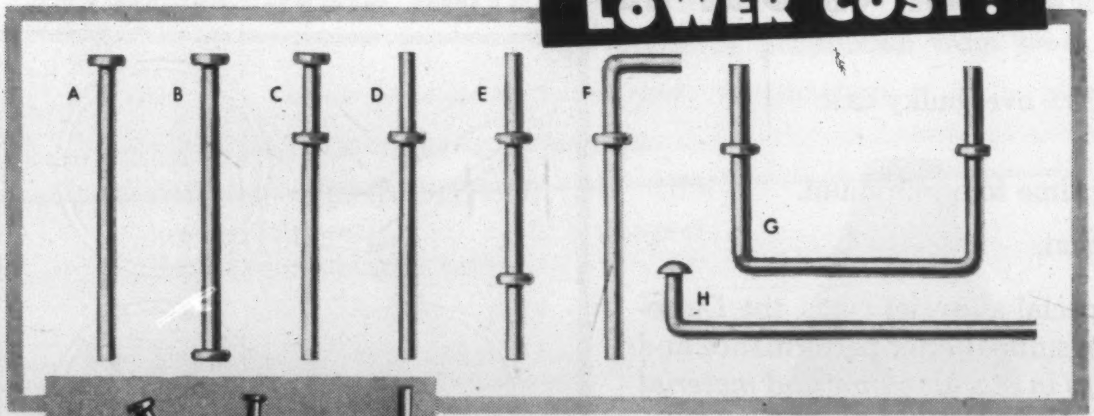

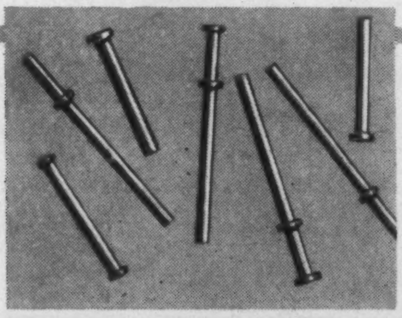

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MATERIALS ENGINEERING NEWS

gram of the National Association of Corrosion Engineers 12th Annual Corrosion Conference. Meetings will be held concurrently with the 1956 Corrosion Show, March 12 to 16, at the Hotel Statler, New York City.

Technical sessions will consist of corrosion developments in atomic energy, high temperature fields, chemical and process industries, metals and plastics, and power and communications. Also scheduled are foreign developments in corrosion control with papers from New Zealand, Israel, and Italy and educational lectures on the fundamentals of corrosion and corrosion protection and control.

The 4-day conference will end Friday with a general corrosion round-table devoted to informal discussion sparked by questions submitted by the audience.

Process Inflates Tubes in Nonferrous Strip

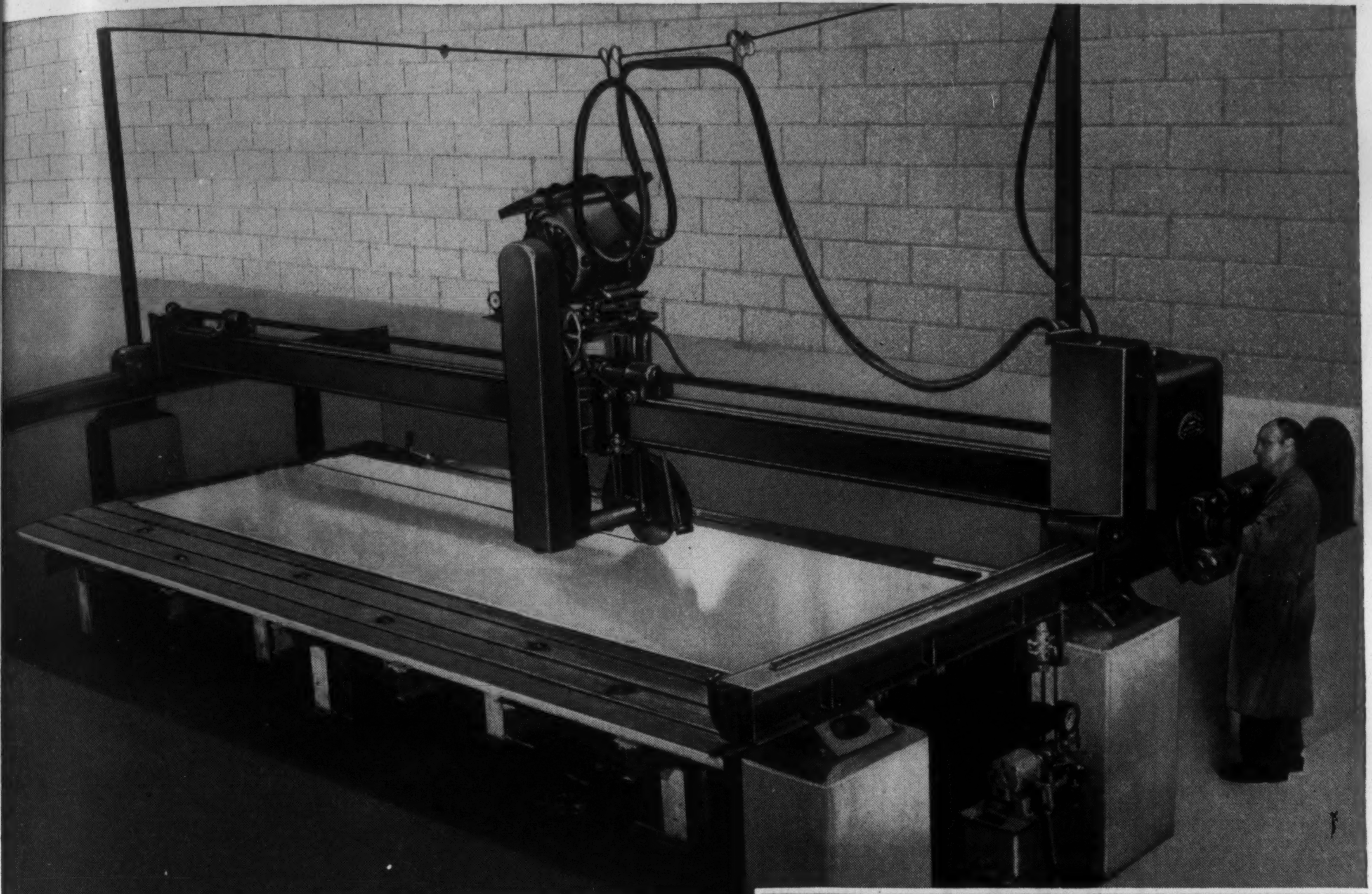
Revere Copper and Brass has introduced a new mill product designated as Tube-In-Strip. The product is a single sheet of solid metal in which tubes are produced by inflating existing channels.

The process involves the insertion of rods of friable materials while the metal is being cast. Castings are then rolled to the desired thickness with the rods crushing to a fine powder during the rolling operation.

Except for the expandable portions, the metal is a solid strip of metal. The channels are inflated by inserting needles into the ends and applying air or hydraulic pressure. Free inflation produces a round tube while a profile die or free inflation between flat plates is used for achieving a variety of designs.

The new product is currently available in copper (deoxidized 85-15), brass (70-30) and aluminum (1100 and 3003). It can be furnished in long coils or in cut flat

FRASSE INSTALLS HUGE ABRASIVE PLATE SAW...



Large plates (up to 240" long) can be cut on this new Frasse abrasive saw. This means fewer welds . . . lower labor costs . . . and a more saleable product.

This huge new abrasive saw . . . a giant in performance as well as size . . . enables Frasse to cut stainless steel and aluminum plates "to-order" from standard stock sizes. With it, plates up to 240" long can be cut—close tolerances can be kept — and square, smooth edges, suitable for most applications without further finishing, can be obtained.

To the fabricator, this means plate deliveries need no longer bottleneck production . . . inventories can be reduced . . . and edge finishing costs may be cut or wiped out completely, simply by phoning Frasse.

So, for dependable service, quick delivery . . . and a product that can contribute to your profit — depend on Frasse. A *choice* source for your stainless steel and aluminum requirements.

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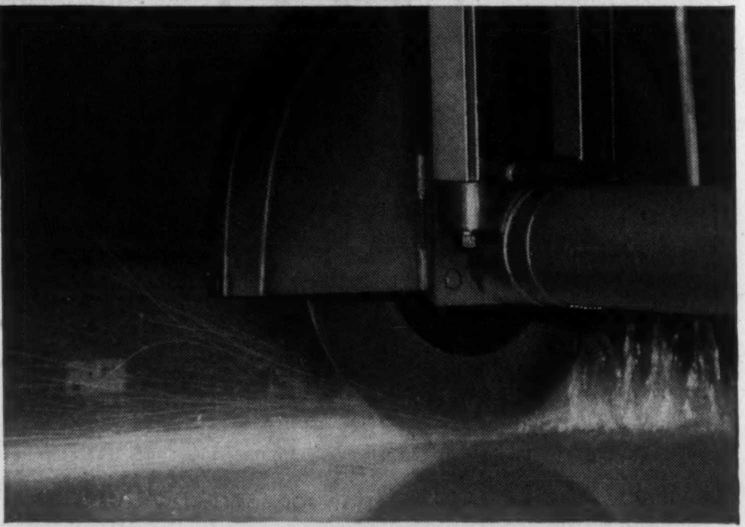

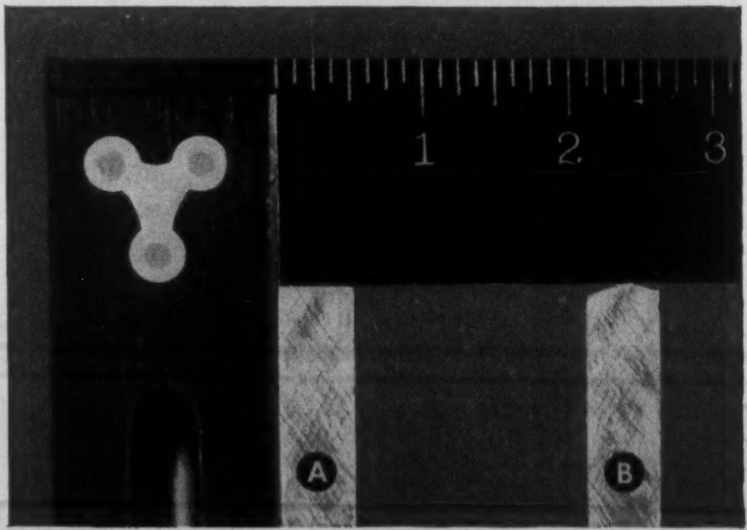

Abrasive cutting offers a superior edge that will in most cases reduce edge finishing costs. Note (a) cut on the new Frasse abrasive saw, (b) cut on a conventional shear.

For more information, turn to Reader Service Card, Circle No. 485

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Contact H & K for any perforated materials your product may require.

No. 00 Straight Holes 952 holes per sq. in. .020" diam. 30% open.

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☐ STOCK LIST of Perforated Steel Sheets
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☐ PRICE INFORMATION (NOTE: Send specifications of perforated materials wanted. If necessary send drawings or sketches.)

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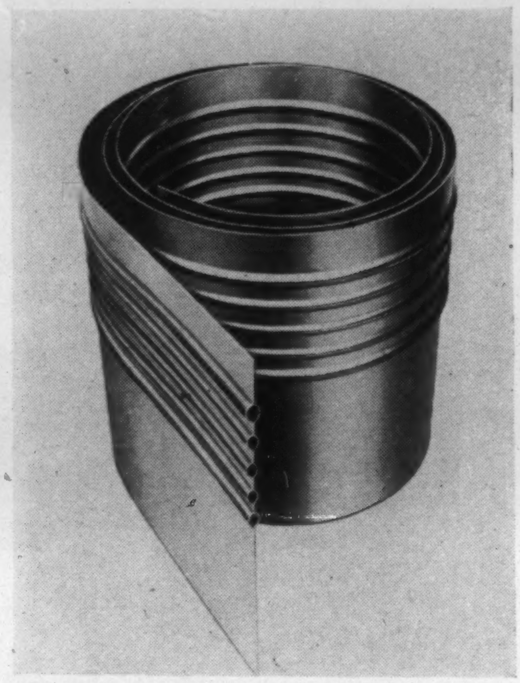
MATERIALS ENGINEERING NEWS



Tube-in-Strip *can be inflated in a coil of any length. Lower half of coil has not been inflated.*

sheets. In copper and brass, strip widths up to 16 in. are available with 30 in. the limit for aluminum. Tube sizes in these metals are 3/16 to 1 in. with tube spacing a minimum of 3/16 in. for copper and brass, and 3/8 in. for aluminum. Minimum web and tube thicknesses for copper and brass are 0.006 and 0.003 in., and for aluminum, 0.020 and 0.010 in., respectively.

Because the inflation technique is simple and flexible, Revere plans to ship the product to the consumer uninflated, thus making possible substantial shipping economies. Uninflated Tube-In-Strip can be handled as easily as any regular sheet metal. It can be stamped or drawn into desired shapes prior to expansion of the channels.

The new sheet material appears to be suitable for applications in the heat exchange field, including refrigeration and air conditioning, chemical, food and petroleum processing, automobile radiators, water heaters and coolers, gas heaters, radiant panel heating and electronics.

(More News on p. 252)

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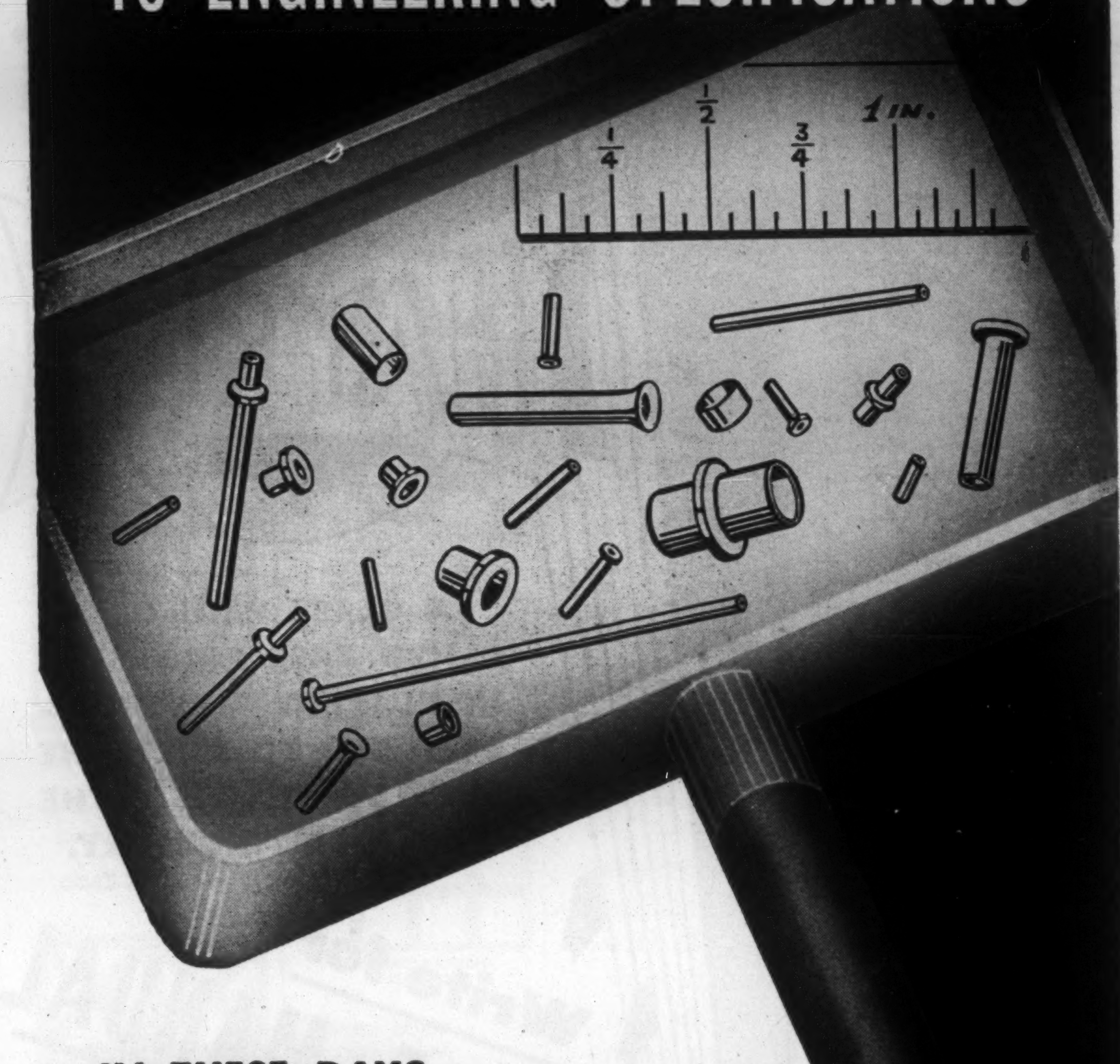

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MATERIALS ENGINEERING NEWS

ASTM Features Electrodeposited Coatings Symposium

The American Society for Testing Materials will hold its 1956 Committee Week and Spring Meeting at the Hotel Statler, Buffalo, N.Y., Feb 27 to Mar 2, 1956. More than 250 ASTM technical committees and their subcommittees are expected to meet during the week to discuss and review the work they have done during the year in preparation for the completion of their year's work to be reported at the Annual Meeting in June.

At an all-day technical session, Wednesday, sponsored by Committee B-8 on Electrodeposited Metallic Coatings, there will be presented a Symposium on the Properties, Tests and Performance of Electrodeposited Metallic Coatings. Eight papers written by outstanding authorities in their respective fields will be presented.

Some of the papers to be presented are:

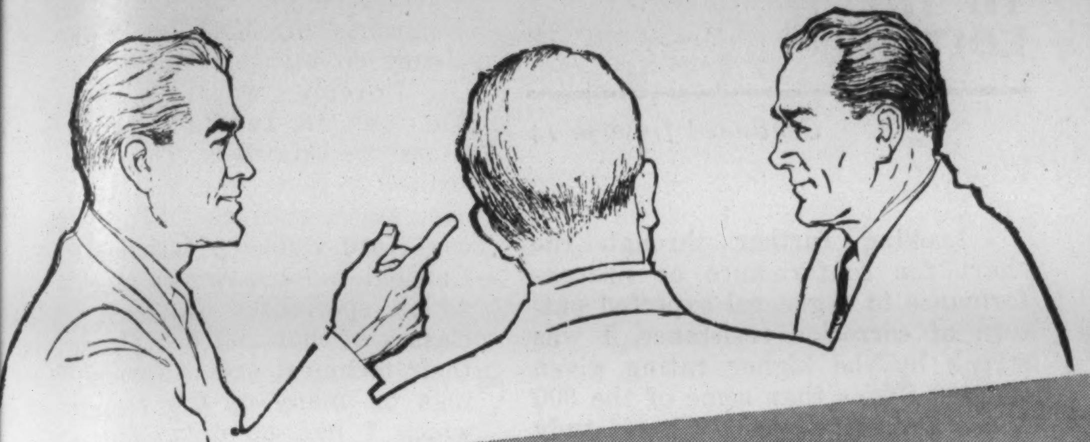
"Corrosion Behavior and Protective Value of Decorative Copper-Nickel-Chromium and Nickel-Chromium Coatings on Steel," C. H. Sample, International Nickel Co.

"Evaluation of Methods Available for Measurement of Surface Luster in Plated Coatings," Glade Bowman, Standard Steel Spring Div., Rockwell Spring and Axle Co.

"Metal Cleaning Prior to Electroplating," S. Spring, Pennsylvania Salt Manufacturing Co.

"Comparison of the Corrosion Behavior and Protective Value of Electrodeposited Zinc and Cadmium Coatings on Steel," C. H. Sample and R. B. Teel, International Nickel Co.; and A. Mendizza, Bell Telephone Laboratories.

"Evalution of Supplementary Conversion Coatings on Zinc and Cadmium," R. E. Harr, Western Electric Co.



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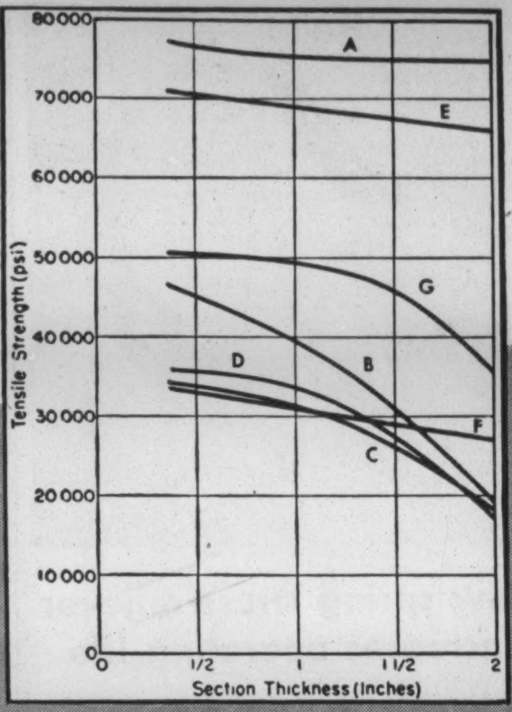
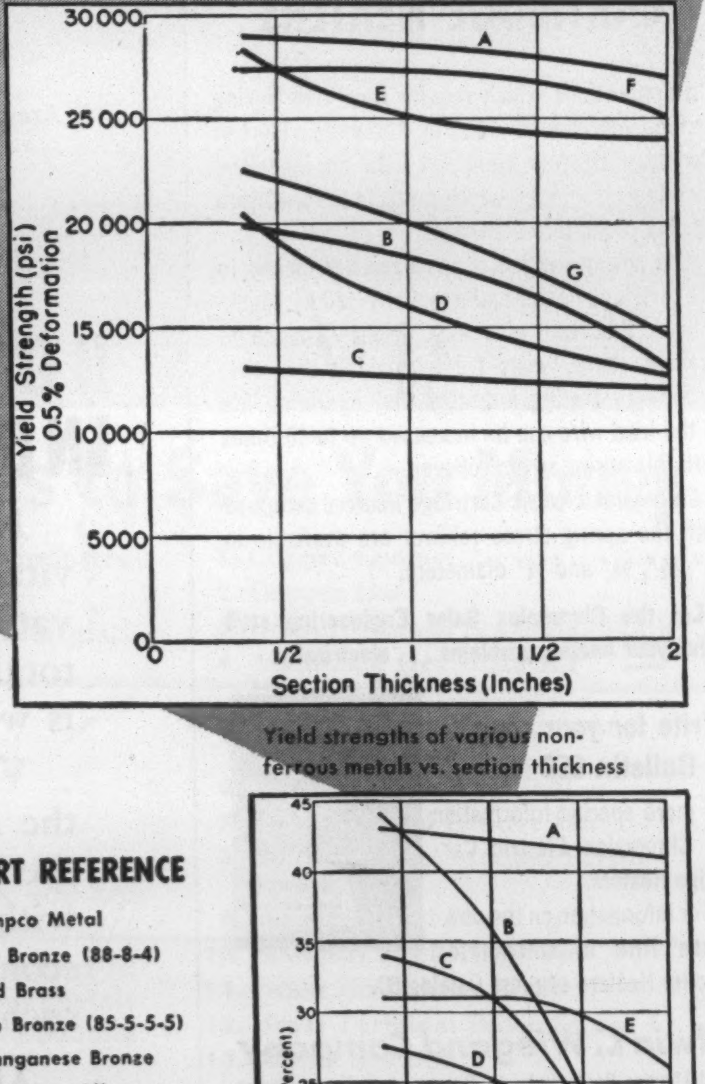


Tensile strengths of various non-ferrous metals vs. section thickness



Yield strengths of various non-ferrous metals vs. section thickness

Examine these charts carefully — they tell a story that can save you money and put extra life and dependability into your product.

Look, for instance, how other non-ferrous metals show a sharp decrease in mechanical values as casting cross-sections increase. Ampco remains practically constant — you require less metal.

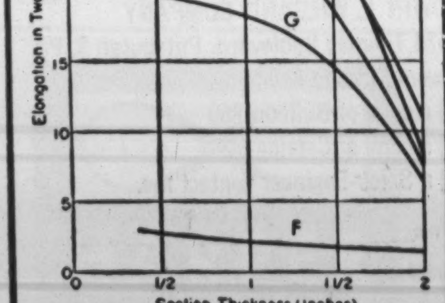
Note Ampco's unusually high tensile and yield strengths compared with conventional bronzes — you use lighter sections to do a better job. And Ampco Metal weighs 10 to 15 percent less than other bronzes — so you can make important weight reductions.

Fact is, Ampco Metal's high strength-to-weight ratios can mean real savings for you — savings in material and money. Consult your nearby Ampco field engineer for full information or write us.

CHART REFERENCE

- **A. Ampco Metal**
- **B. Tin Bronze (88-8-4)**
- **C. Red Brass**
- **D. Tin Bronze (85-5-5-5)**
- **E. Manganese Bronze**
- **F. Aluminum Alloy**
- **G. Silicon Bronze**

Charts courtesy Materials & Methods and Westinghouse Electric Corp.



Elongations (2") of various non-ferrous metals vs. section thickness

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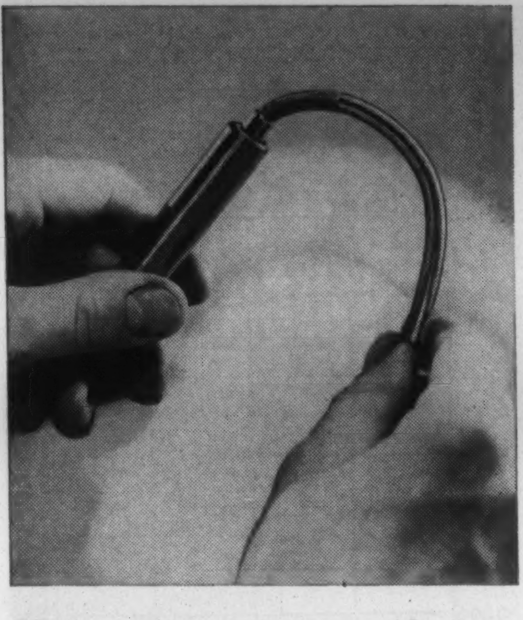


New spring stress reliever increases operating life

CHROMALOX *Electric* CARTRIDGE HEATERS

On applications which require repetitive flexing action, you can now obtain Chromalox Electric Cartridge Heaters equipped with an ingenious high tensile spring—which protects the lead wire against premature breakage.

The spring—which is mechanically locked to the cartridge heater and is not affected by heat—follows the lead wire a sufficient distance to prevent sharp twists from breaking the wire. Laboratory testing indicates that operating life of the lead wire can be increased up to 10 times with this spring stress reliever.

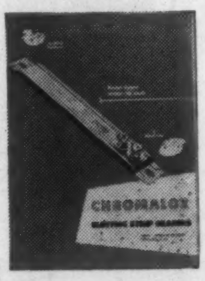
Chromalox Electric Cartridge Heaters equipped with the spring stress reliever are available in ⅜", ½", ⅝" and ¾" diameters.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically.

Write for your copy of Bulletin 850

for more specific information on Chromalox Electric Cartridge Heaters.

For information on the complete line of Chromalox Electric Heaters request Catalog 50.



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LETTERS TO THE EDITOR

Continued from p. 14

Looking further through the chart for conformance or nonconformance to a general expected pattern of corrosion resistance, I was struck by the higher rating given the 400 Series than some of the 300 Series for butyric acid. Closer study will, I am sure, reveal numerous similar seemingly inconsistences.

Above and beyond these specific comments, there is, of course, the problem of varying corrosion resistance in relation to any corrosive media based on temperature and concentration conditions. This is acknowledged in the upper left-hand corner of page 124 of the article, but I wonder if such a side note would be observed by the average reader.

Richard E. Paret
Committee on Stainless Steel Producers
American Iron and Steel Institute
New York, N. Y.

To the Editor:

Thank you for forwarding the comments of Mr. Paret and Mr. Henry on my corrosion article.

In reply I would like to say that the chart was based on a study of the literature originally. Then the skeletonized version was sent to various companies, such as DuPont, American Hard Rubber, National Carbon, Carpenter Steel, Ampco Metals, etc., which specialized in each of the classes of material being rated, and their technical people furnished ratings on many of the reagents for which I had no data. The various companies also corrected any mistakes they found in the original draft of the chart, in their opinion, that is.

Some of the original sources for compilation of the chart I can remember offhand were Carpenter Steel's "Working Data for Carpenter Stainless & Heat Resisting Steels"; Hills-McCanna Co.'s product catalogue which contains an excellent chart on rating materials vs corrosive media; various International Nickel Co. publications covering monel, Inconel, etc.; Uhlig's "Corrosion Handbook"; Speller's "Corrosion, Causes & Prevention"; American Hard Rubber Co.'s data book on

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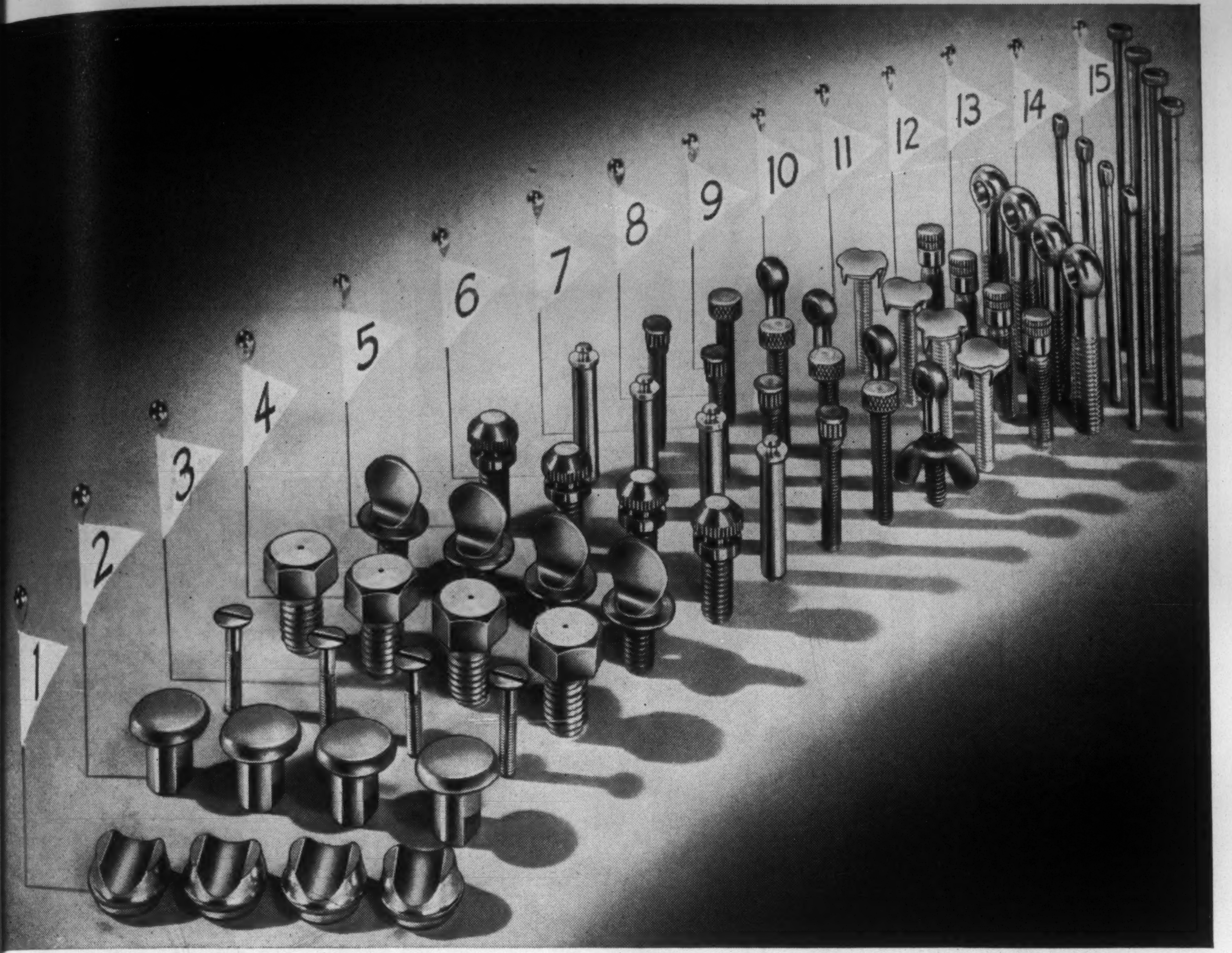

This Army of Specials Marches to Save You Money

Here are a few of the many specials produced by Harper to save industry money—to do a better job.

Many used to be milled from bar but Harper engineers and metallurgists developed methods of cold-forming them with these results:

- Important savings in cost
- Faster production
- No metal wasted
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- weighing 10,000 pounds each
- alloyed 25% Cr — 12% Ni
- for 1750°F. temperatures

DURALOY

These stools should offer a very pertinent tie-in with your casting requirements. Essentially, they are alloyed to resist heat. They're typical of the heavy high alloy castings we are equipped to turn out.

They will serve also to indicate what we can do in the way of producing castings to resist not only high temperatures but severe corrosion or combinations of heat and corrosion, as well.

Today, we can offer several distinctly different types of castings in the high alloy field including static, centrifugal and shell-molded.

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LETTERS TO THE EDITOR

Continued from p. 254

hard rubber; Anaconda's "Corrosion Resistance of Copper Base Alloys"; "Metals Handbook"; and "Corrosion of Metals" published by ASM.

RUSSELL W. HENKE
Chief Engineer
Seaman-Andwall Corp.
Milwaukee, Wis.

The editors had some misgivings about publishing the chart listing the relative corrosion resistance of a number of different materials to various media. We were well aware that ratings of this sort are open to wide disagreement and vary considerably, depending upon specific service conditions. That is why we printed an explanatory note cautioning readers not to use the ratings without further investigation. It is also why we wrote to the author before we published his article, expressing our reluctance to include the table. The following was his reply.

To the Editor:

I am well acquainted with the objections expressed in regard to corrosion charts of the type to appear in my corrosion article. I have, as a matter of fact, expressed similar ones myself. On the other hand, I have also been glad to use just such a table in the absence of either specific information or experience.

I think the point to be stressed in printing a table of this sort is that the information is intended as a guide only and couldn't possibly be made universal under the circumstances of its presentation. It is all well for corrosion authorities to criticize such a table, but for the lay operator, the information is quite welcome. Actually, many corrosion experts have resorted to the same device in presenting some of their work.

I am of the opinion that the table would be of value to the people for which the article was intended—the average design engineer with little or no background in corrosion. Perhaps a strong emphasis should be placed on the generality of such a table and, in particular, the unpredictable behavior of media such as the acids, so the designer would go to more authoritative sources in these specific cases.

RUSSELL W. HENKE